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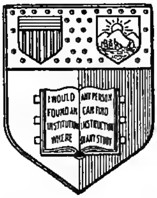
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RHODOLOGIA.

A DISCOURSE ON ROSES,

AND

THE ODOUR OF ROSE.

BY

J. Ch. SAWER, F.L.S

AUTHOR OF "ODOROGRAPHIA.")

Brighton:
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PREFACE.

By referring to the table of General Contents on the next page, it will be perceived that the intention of these few Rose-leaves (culled from plants of many countries) is to interest persons located in some of our Colonies where the climate, etc., is suitable to the development of the Rose.

The Rose Industry is capable of great extension, and the demand for the products of this flower is increasing.

Details are also given which are intended to interest students, manufacturing chemists, and buyers of rose-products. Statistics of trade, recent discoveries, patents, etc., are, as far as possible, recorded right up to date.

Classification and cultural instructions respecting hybrid roses grown for purely ornamental purposes are not here included. That work has already been very ably accomplished by several eminent authorities who have made it their especial study. Lists of new roses are also given in the Annual Reports of the National Rose Society and in their Catalogue of Exhibition and Garden Roses.

Brighton, 17th Sept., 1894.

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GENERAL CONTENTS

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RHODOLOGIA.

THE great perfection to which rose growers (amateur and professional) in England, Belgium and France have now brought this magnificent flower is indeed marvellous; the number of distinct varieties named and cultivated is over 7,000, and with every horticultural exhibition this number is increased to such an extent as to justify the existence in England, France, and Germany of periodical publications exclusively consecrated to the "Queen of Flowers." In fact, there seems to be no end to what rose growers can do in the way of novelty. A leading London paper, commenting on a show of the National Rose Society, gives a glowing description of such novelties as the creamy, claret-tipped "Princess of Wales," the shell-white "Hon. Edith Gifford," the ivory Tea-rose "Souvenir de S. A. Prince," the pink-copper "Lady Penzance," and the exquisite double-yellow "Rosa Sulphurea," and remarks:—"What immortality can be more charming than that which is thus conferred by coupling some happy name with a new favourite in the world of roses."

Many a London house during the month of June, at the festal hour, is converted into a perfect Gulistan with this most delicate and most delicious of ornamentation. Some of them almost rival the lavish prodigality of ancient times. Cleopatra, according to

Athenæus, more than once covered the floor of her dining-hall with roses a cubit thick, and the Emperor Nero expended in one feast as much as £30,000 in roses alone; while everybody remembers the gorgeous canvas upon which Mr. Alma Tadema delineated Heliogabalus overwhelming his guests with an avalanche of roses showered from above. But the ancient rose lovers never possessed or saw blooms of their favourite flower half so perfect as those which are to-day quite common. They knew next to nothing of the amazing modern variety in the Queen of the Garden—white roses, blush roses, pink roses, pied roses, crimson roses, scarlet roses, vermilion, claret, carmine, purple-striped, and black roses, and roses of burning bronze and silver satin. Many a cottager has to-day upon his wall a "Cloth of Gold" rose such as the Cæsars could not have bought for a thousand sesterces; and, beyond question, the finest roses in the world are to be seen in London during the months of June and July.

Well is it said by the Dean of Rochester, in his perfectly charming "Book about Roses,"* that "he who would have beautiful flowers in his garden must have them in his heart." In this work, abounding in information concerning the culture of the choicest specimens of roses, are also to be found many anecdotes of those who have loved roses, and been successful with them (not by any means always the rich or the learned). The very reverend author tells a story of a Nottingham mechanic whose wife, with his entire consent, took a blanket from their insufficiently supplied bed to keep the frost out of the little green-house where they had their rose stocks. He tells us also how, at a June show of the Manchester Botanical Society, £1,100 was paid by the working-classes in single shillings to see the glory of the prize blossoms. Delightful indeed is the enthusiasm to which such a lover of the imperial flower attains! If once, indeed, a man is bitten with the passion for cultivating high-bred roses, anything like a cure of it is hopeless. The Dean himself confesses that, though he commenced with a

* London, 13th Edition.

dozen plants only (the first which enslaved him being the "D'Aguesseau Gallica"), he did not become contented when he owned 5,000. Master of many rosy legions, he frankly declares that if he had Nottinghamshire full of roses he would still desire to have Derbyshire for a budding-ground. If a grave and pious dignitary of the Church can fall into the splendid horticultural avarice indicated here, laymen may well be warned not to abandon themselves too lightly to the fascinations of the Rêve d'Or, La Belle Lyonnaise, or Souvenir de Malmaison.

Notwithstanding this great enthusiasm, it seems that both cultivators and admirers of this flower concentrate their whole attention on the development of colour, form, and size, and pay little heed to the great *variety of perfumes* generated in the beautiful petals. These different odours (although, of course, *blended* with that of rose) are distinctly recognisable, and are in some cases very marked.

The organs of the sense of smell can be trained to the *appreciation* of perfumes, especially by young persons, as easily as the palate can be trained for business purposes to the tasting of the flavours of wines, tea, or coffee. Of course a taster, sampler, or evaluer of such beverages must naturally be possessed of a finely developed nervous susceptibility to the slight variations occurring in every sample which comes under his notice. Such natural perfection of susceptibility is not common, although many possess the gift without being quite aware of it: they may not be in the tea trade or the wine trade, or in any trade at all; and so the gift is not trained, or even appreciated. To those who are not constantly occupied in the culture of the rose, it may seem that one rose is very much the same as another, and excepting a few variations in colour and habit of growth, there is very little difference distinguishable. Probably many persons would never believe that there are not only roses perfectly devoid of odour, but there are some which stink. There are experienced gardeners who can *name* many varieties of rose in the dark: this means that the perfume of roses is very varied, and that no two varieties possess the same odour. What is called the *pure* odour of rose is unique, undefinable, incomparable. It is, in fact, a *type*, and no imitation can approach it. It may be best represented by the *R. centifolia* and *R. Damascena*.

R. centifolia, Lin. Sp. 704* (*R. provincialis* Miller), is found in the wild state, with single flowers, in the eastern parts of the Caucasus.† Under cultivation its flowers are more or less double, and innumerable varieties of it are propagated and grown in every temperate region of the globe. In English gardens it is grown as the Cabbage Rose or Provence Rose. In the South of France it is cultivated commercially.

The second type of a pure rose odour is represented by the plant grown in Bulgaria; this is a variety of the *Rosa Damascena*, Miller.‡ Living specimens were sent from Constantinople by Professor Baur; these flowered at Tübingen, and were examined and identified by Hugo Mohl.§ *R. Damascena* is not known to exist in the uncultivated state. Koch‖ affirms that at a remote period it was brought from Italy into northern countries. Baker¶ considers *R. Damascena* to be merely a variety of *R. Gallica* which was distributed from France to Mesopotamia.

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* P. J. Redoute, "Les Roses" Paris, 1817 and following years. Text by Thory; i. p. 25, t. i. p. 37, t. 7; p. 77, t. 26; p. 79, t. 27; and p. 111, t. 40. † Boissier, Flora orientalis, 1872, ii. p. 676. ‡ Redoute, as above, i. p. 137. t. 53; i. p. 107, t. 38; and i. p. 121, t. 45. Also Lawrence, "Collection of Roses from Nature," London, 1799, t. 38. § Wiggers and Husemann, Jahresbericht, 1867, p. 350. ‖ Dendrologie, 1869, i. p. 250. ¶ Journal of Botany, Jan., 1875.

For description and classification of roses the following works may also be referred to:—Guillemeau, Histoire Naturelle de la Rose, 1800; J. P. Buchoz, Monographie de la Rose, Paris, 1804; Raw, Enumeratio Rosarum, Wirceburg, 1816; Pronville, Nomenclature Raisonnée des espèces, variétés, and sous-variétés du genre Rosier, Paris, 1818; John Lindley, Rosarum Monographia, London, 1820; L. Trattinick, Rosacearum Monographia, Vienna, 1823; Hariot, Notes, pour servir à l'historie des classifications dans les espèces du genre Rosa; Thèse de l'Ecole de Pharm. de Paris, 1832; Boitard, Manuel complet de l'Amateur de Roses, Paris, 1836; Deséglise, Catalogue raisonné des espèces du genre Rosier, Paris, 1877; Chereau, Examen des roses officinales; Journal de Pharmacie, xii. p. 436; S. Reynolds Hole, A Book about Roses, 12th edition, London, 1892. Good lists of new varieties are also to be found in the catalogues of Louis Van Houtte, of Ghent.

The first attempt to classify the *varieties of perfume* in the rose was made as recently as 1886, by an anonymous writer in an American horticultural journal.* The subject was further studied by Dr. Blondel in 1889,† and reprinted in his admirable treatise, "Les produits odorants des Rosiers," Paris, 1889.

These observers record the fact that the odour of tea is not perceptible in the so-called "Tea-roses," indeed many Tea-roses are odourless, such as the *Mélanie Souppert, Marie Guillot, Marie Caroline de Sertoux,* and *Triomphe de Milan.* Some Tea-roses possess very delicate fruity odours; for instance, the *R. Socrates* has the odour of peach; *Elizabeth Barbenzien,* odour of melon; *Isabelle Narbonnand,* odour of violet; *Safrano,* odour of pinks. Some of the Tea-roses possess odours which are far removed from that of pure rose, but yet are particularly sweet and fruity, recalling that of the raspberry, such as the *Maréchal Niel* amongst the yellow, *Goubault* amongst the red, and *Madame Bravy* amongst the creamy-white varieties. There are Tea-roses such as *Gloire de Dijon.* whose perfume is so sweet and subtle, that any definition or comparison is quite impossible.

The majority of Noisette roses are inodorous, but the variety known as *Unique jaune* has a faint odour of hyacinth, and some, such as *Celestine Forestier, Claire Carnot,* and *Earl of Eldon* have a slight fruity odour; this is particularly noticeable in the *Desprez.*

Amongst roses possessing fruity odours, *R. bracteata* and *R. Macartnea* are credited with possessing the odour of apricots, and *Souveraine* (a cross between a Tea-rose and *R. centifolia*) has exactly the odour of melons; in most cases, however, the fruit odours are blended with one somewhat analagous to that of bananas or quinces. The odour of mignonette is noticeable in *R. canina* (especially when the petals are developed in a somewhat darker shade than usual), the red *R. sæpium,*‡ and *R. Alpina,* Lin. (This last is now employed in the perfume industry specially by reason of its mignonette-like fragrance.)§

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* The Gardener's Monthly and Horticulturist, xxviii. 1886, p. 249, Philadelphia. † Bull. de la Soc. Bot. de France, Fevrier, 1889. ‡ Sowerby, Eng Bot. Sup. t. 2653. § Bot. Reg. t. 424.

The odour of violet, besides being developed in *R. Isabelle Nabonnand*, above-mentioned, is also very noticeable in *R. Banksia alba.* (*Banksia lutea* is perfectly inodorous.) The odour of pinks is also exhaled by the *R. caryophyllea*, *R. Ripartii*, Deséglise, and *R. moschata*, Miller. This last, however, does not possess the odour of musk, as one might suppose by the name. The musk odour is only clearly developed in the *R. Salet*, a hybrid climbing Moss-rose, bright red with a pale centre.

The flowers of most of the varieties of *R. rubiginosa* are inodorous, but those of *R. platyacantha* and *R. Capucine* (*R. Eglanteria*, Lin.), (especially the variety *bicolor*, Jacq.) belonging to this group, develop an odour of bugs and coriander. The same may be said of *R. Beggeriana* (*R. coriosma*, Decsn.).*

In further illustration of the capricious nature of this perfume, and the extraordinary complexity of its forms, it is stated that not only in the whole list of roses are there no two which develop precisely the same odour, but that in the same species, and even on the same plant, there are not found two flowers absolutely identical in odour,—even yet further, that it is a well known fact amongst rose growers that at different times in the day an individual flower will emit a different perfume.

As a rule the red roses are more odoriferous than the white.

Cut roses placed in a vase diffuse their fragrance more powerfully than when growing on the plant.

It has also been noticed that roses flowering under glass give off a greater amount of perfume than those cultivated in the open air; the reason of this is obscure, but it is perfectly certain that under no conditions is the odour fully developed except in very hot climates, where the power of the sun affords the maximum benefit of light and heat.

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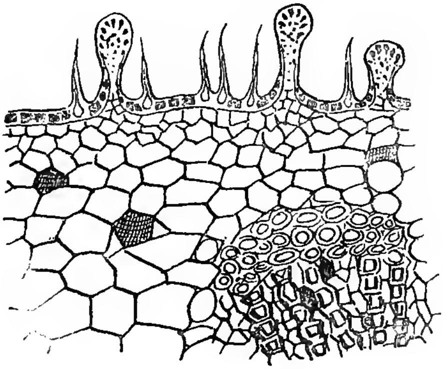
* This is a very remarkable coincidence ; the coriander plant and its unripe fruit both possess the intensely disgusting odour of bugs, but the fruit at complete maturity, acquires the pure odour of coriander. The nature of the chemical action producing this modification in the odour is not understood An equally curious example of the transmutation or development of odours is instanced in the *Acacia Farnesiana* and the *Tritelia uniflora*, in both of which plants are associated the odours of violet and of garlic.

The flowers of *Rosa gallica* (which are used officinally) are but feebly odoriferous when freshly gathered; their perfume develops gradually in the process of desiccation, while that of the Damask-rose is almost destroyed by drying.

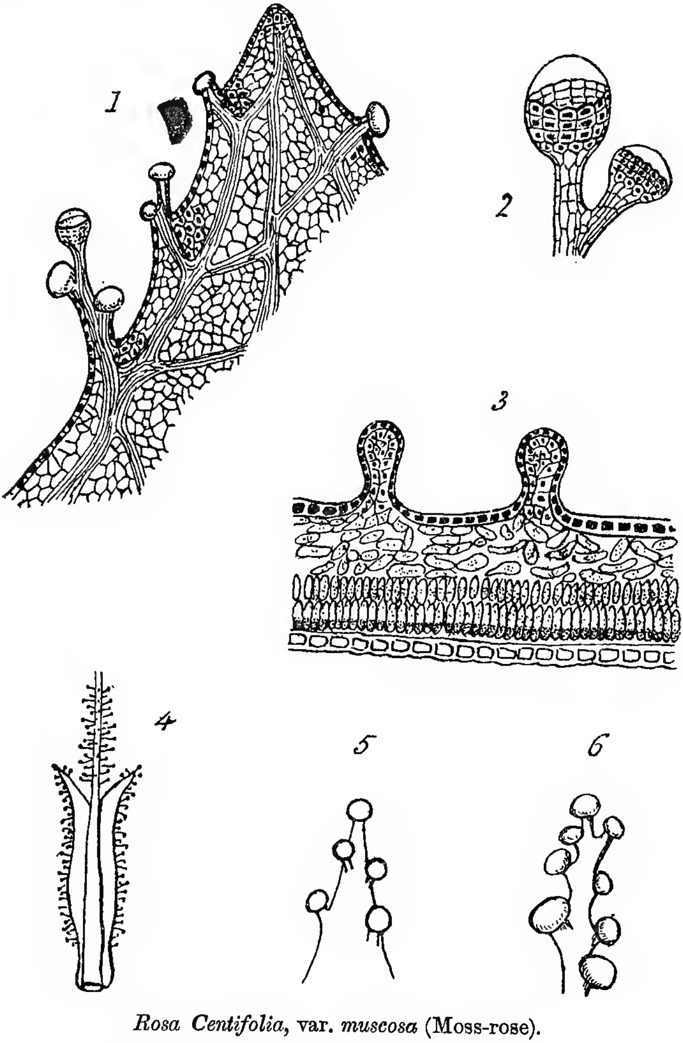
In Bulgaria the flowers grown for the distillation of the otto are gathered before they fully expand, and a little before sunrise. Were they gathered later in the day, when fully expanded by the heat, the perfume would be weaker, and not so sweet, and the resulting essence would be of less value.

It has been noticed that previous to a storm, or atmospheric disturbance, the odour of the rose seems strangely increased; this may be by reason of the oxidising influence of the ozone in the atmosphere, or it may be that our perceptive faculties are sharpened at such moments.



Rosa centifolia. Transverse section of a sepal, showing the pedicellate glands on surface of epidermis, and fibro-vascular bundle within. (After Blondel.)

In estimating the quality of the odour of a rose, care should be taken in handling the stalk, the calyx, or any green part, as a very slight friction breaks the pedicellate glands which abound on these parts, and in which is secreted an oil or glutinous oleoresin of powerful odour, totally different in character to that developed in the microscopic cells of the petals. In some roses.



Rosa Centifolia, var. *muscosa* (Moss-rose).

Fig. 1.—Single tooth of a foliole (× 80) showing the pedicellate and branched glands on the margins of the tooth, and non-existence of same at the summit. The dark coloured cells at the summit of the tooth and at the base of the glands are cells secreting tannin.

Fig. 2.—A single gland of the above, isolated and greatly magnified, showing the tannin-secreting cells at the base rendered opaque by their contents, and the upper cuticle raised by the accumulation of oleo-resin at the summit.

Fig. 3.—Transverse section of a foliole. (This drawing is inadvertantly made upside-down.) It shows the pedicellate, oleo-resin secreting glands on the *lower* surface, and the structural difference of the upper and lower parenchymatose tissue (× 300).

Fig. 4.—Base of a petiole, showing the stipules, and how the entire formation is clothed with pedicellate glands.

Figs. 5, 6.—Glandulous structures occurring in large quantities amongst the prickles and young thorns.

such as the Moss-rose, these glandular formations attain quite a prodigious size, developing very rapidly on the young shoots, even overtopping the thorns. In some varieties the odour of the glandular secretion is very rank, and has been described as hot, peppery, clove-like and terebenaceous, but the word terebenaceous is misplaced and misleading; the odour may remind of the resins contained in certain woods, but it is generally more *balsamic,* like the odours of some varieties of pelargonium and geranium leaves. In some varieties of the group *Rosa villosa* the odour approaches that of olibanum and myrrh. In *R. Brunonii,* Lindl. (a moss variety of *R. moschata,* Miller), the hispido-glandulous system which thickly covers the pedicels and sepals, develops a fine odour of pinks. Sometimes this odour is fruity, as in many varieties of *R. rubiginosa,* Lin. (the "Sweetbriar") and is developed to such an extent as to be disengaged spontaneously, especially on a warm day, and by the gentle action of the wind after a light rain. All the green parts, especially the lower part of the leaves, contain innumerable oil glands, which, being broken by the slightest friction, exhale an agreeable odour which has been very rightly compared to that of an apple called "Pomme Reinnette," or in English "Pippin." The glands of *R. micrantha,* Smith; *R. graveolens,* Pers, and *R. glutinosa,* Sibth. secrete a very similar perfume. The composition of the body contained in these glands is apparently unstudied and little understood, but its odour is suggestive of *valerianate of amyl*, which is now prepared on a large scale for use in flavouring sweetmeats and liqueurs with the flavour of apples.*

The leaves of *R. lutea*, Dalech (*R. Eglanteria*, Lin.), (known also as *R. Capucine*) possess an odour which is even finer, recalling that of jasmin.

The glandular structures of the green parts of the rose are minutely described by Dr. Blondel in his work above cited, he also gives details of the cellular arrangement of the epidermis of the petals, and illustrates the appearance of the same under the microscope (the accompanying illustrations are copied therefrom). He found on examining the anatomical structure of a transverse section, that both sides of the petal are equally odoriferous, that is to say, the otto is secreted in epidermal cells on both surfaces, the upper ones being papillary, and the lower ones cubic, in form. To exhibit the presence of the oil, he employed a reagent of great sensitiveness, viz., a solution of osmic acid ($Os\ O_4$), 1 in 200. The section of a fresh petal is plunged in this bath for about twenty seconds, then carefully washed in distilled water and mounted in glycerine. Thus prepared, and examined under the microscope, the cells of both surfaces of the epidermis appear to be filled with an intense bluish-black pigment, due to the reduction of osmic acid by the essential oil and deposition of the osmium. The mass of osmium thus deposited is quite homogeneous in appearance, and this is thought to indicate that the oil exists in a very minute state of division, and not agglomerated in drops, as in the pedicellate glands on the leaves and other green parts of plants. In sections of plants containing essential oil in an agglomerated mass, or even in rather large drops, the action of osmic acid is very different. For example, if a section of a leaf or petal of the orange plant be treated with this reagent, the osmic acid coming in contact with the drops of oil, is only reduced by the smallest drops or particles of the oil, leaving the other drops intact and unacted upon. This is further exemplified by placing side by side, and in contact, on a slip of glass, a drop of otto of rose and

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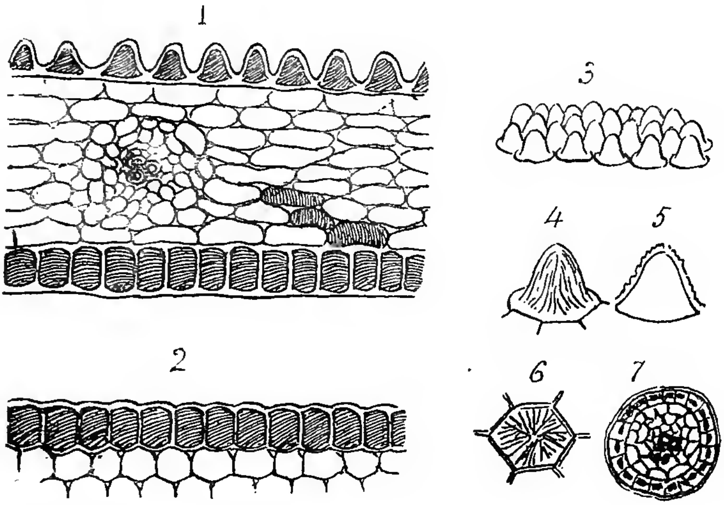
* A similar odour has been noticed in *phenylnitro-ethylene chloride*, which can be prepared by passing chlorine into a cooled solution of phenylnitroethylene in chloroform. On the evaporation of the latter it remains as a thick oil, which has a penetrating odour, resembling, when dilute, that of *pippins*. On standing for some time, large lustrous crystals are deposited, which are extremely soluble in ether and chloroform, and are again left on evaporation as an oil, which solidifies, when placed in contact with a fragment of the original crystals, to a mass, which melts at 30°. This odour of pippins, akin to that of sweetbriar, is noticeable in the flowers of *Agrimonia eupatorium*, and in all parts of the *Agrimonia odorata*.



Rosa centifolia.

Fig. 1.—Transverse section of a petal (×500,) after treatment with osmic acid; showing the reduction of the osmium in the vessels on both surfaces.

Fig. 2.—Fragment of section of a petal at the part where it is attached to the calyx, showing (×500) the non-papillary cells of the upper epidermis filled with essential oil.

Fig. 3.—Fragment of upper epidermis of a petal, dissected under the microscope, showing the formation of papillary cells.

Fig. 4.—A single cell (×1000).

Fig. 5.—Longitudinal section of same, and Fig. 6 upper view of same.

Fig. 7.—Transverse section of filament of stamen, after treatment with osmic acid, showing the essential oil contained in the epidermal cells (×200).

a drop of osmic acid solution (even a concentrated solution), the reduction only takes place at the points of contact of the two liquids, and for the reason that they are not reciprocally miscible one with the other. To produce the complete reaction, it is necessary to actively stir the mixture of the two liquids with the point of a needle in order to produce an intimate mixture or emulsion of the oil in the aqueous solution, and so to multiply the points of contact with the reagent; the mixture then blackens almost immediately. From this experiment we can draw a conclusion of great importance as regards the elementary biology of the epidermal cell of the petal; viz., that as the osmium is reduced with the rapidity above stated, it is evident that the oil is located equally at all points of the substance of the phytoblast, and exists in a state of extreme division, so permitting contact to be established at innumerable points simultaneously. This proves that the cell is not only the reservoir or containing receptacle of the oil, but that it is in fact the *seat of its manufacture,* the actual locality where it is generated by a natural synthetic process, and not the simple container of products elaborated in sub-adjacent tissues. It is also inferred that as this oil does not accumulate or take the form of drops, it is given off as an odorous emanation almost as soon as it is generated, and that the formation and the dispersion by exhalation proceed simultaneously. Hence the flowers soon lose their perfume after being cut. This feasible theory applies to many other odorous flowers which *exhale* their perfume, are not furnished with receptacles to *store* their oil, and therefore cannot yield oil on distillation (or at all events very little). Considering this structural arrangement, it is not surprising that the quantity of essential oil obtainable from the rose is so very small, and if not immediately distilled the yield is even smaller. The perfume exhaling from many other flowers, such, for instance, as pinks, stocks, hyacinths, and in some instances from leaves, such as *Mimulus moschatus* is doubtless referable to the same cellular formation. Such flowers as those of lavender, and such leaves as those of mint, thyme, and geranium are furnished with cells and glands which *store up* the oil, consequently their perfume is only perceptible when these vessels are ruptured by friction. The conditions in which the various oils exist in the plant and their liability to be more or less changed or damaged by the action of heat, of course guide the manufacturer as to the process he shall adopt to extract the products.

It may be remarked that as osmic acid is reduced by fixed oils and by tannin as well as by essential oils, the presence of stereoptene in the rose petals may have interfered with the accuracy of Blondel's observations, and that the conclusion he arrived at, viz., that the otto is produced in the cells of *both* surfaces, may be erroneous; in any case, it has more recently been affirmed by Mesnard that the essential oil of rose is found in the papilliform epidermal cells on the *upper* surface of the petals, and scarcely ever on the lower side.*

Mesnard conducted his investigation in the Botanical Laboratory of the Sorbonne, under the direction of Gaston Bonnier. His interesting and suggestive memoir may be abstracted as follows :—

"The imperfection of the micro-chemical methods usually employed has hitherto prevented an exact knowledge being obtained of the manner in which the perfume of flowers is generated (and localised in the flower). In this particular investigation I have followed the same method of research which was adopted in the localisation of fixed oils. The method is as follows :—The section being placed in a drop of pure glycerine is arranged upon a round cover-glass, which being then inverted, serves as a cover to a small chamber formed by cementing a glass ring to an object-slide. In the interior of this chamber is fixed another ring of smaller diameter, and somewhat less in height, thus forming an inner annular space in which the reagent may be placed. By adopting this arrangement the light passing through the central part of the cell is not weakened. The inner ring further serves to support a very small cover-glass upon which sections may be arranged which require to be exposed to the action of the reagent for some length of time, as occasionally happens in the case of fixed oils. The reagent invariably employed is pure hydrochloric acid, the hydrated acid vapours abundantly given off from which are absorbed with avidity by the glycerine. In this way, by a gentle and easily regulated action, I obtain complete hydration of sections in the presence of an acid. After a few moments of exposure to the presence of the reagent, the essential oils appear as minute spherical drops of a fine transparent golden yellow. If the action be prolonged, the drops disappear, being transformed into diffusible products. The disappearance or diffusion of globules of fixed oils never takes place, the process thus furnishes a means of distinguishing these two classes of products.

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* Recherches sur le mode de production du parfum dans les fleurs, Note de E. Mesnard, présentée à l'Académie par Duchartre. Comptes Rendus, 21 Nov., 1892, cxv., p. 282.

" As regards the localisation of essential oils in the parts of the flower, the following observations have been made :—

" *Jasmin.* In this flower the oil is situated in the row of epidermal cells on the *upper* side of the sepals and petals. Some exist also in the corresponding layer on the under surface, where the sepals are coloured by a violet pigment. If the evolution of the cell contents in flowers at different stages of development be followed, at first nothing but chlorophyll is found in the tissue; tannin is the next to appear, or rather intermediate glucosides, difficult to identify by means of the ordinary tests for these substances. These glucosides furnish the tannin and pigments of the lower surface of the sepals. The hydrochloric acid vapours furnish a means of distinguishing all the tannoid compounds intermediate between the chlorophyll and tannin, or pigments, on the one hand, and between the chlorophyll and essential oil on the other. The explanation of these facts seems to be as follows :—Whereas, upon the lower surface, which, in the bud, was exposed to the action of light and the oxygen of the air, the tannoid compounds were slowly oxidised, thereby generating tannin, the *upper* surface, on the contrary, being then hidden inside the bud, these agencies were inoperative (the parts not being exposed to the action of light and oxygen), and the same compounds were converted into essential oil, which oxidises when in contact with air, and so produces the sensation of perfumes."—[This confirms the theory of Liebig and others, that perfume is the result of eremacausis.]

He then states his opinion that the essential oil is generated in the rose precisely in the same way as in the jasmin; also from his investigations he draws the following conclusions:—

"1°—That the essential oil is generally found localised in the epidermal cells in the upper surface of the sepals or petals, though it may exist upon both surfaces, especially if the floral organs are completely hidden in the bud. The lower surface generally contains tannin or pigments derived from it.

"2°—The essential oil seems in all cases to be the result of a transformation of the chlorophyll. This transformation is readily understood if it be admitted, as it generally is, that the floral organs are but leaves modified for the performance of a new function. The chlorophyll being thus diverted from its original purpose or use, is transformed into permanent tannoid compounds or into essential oils.

"3°—The liberation or disengagement of perfume from the flower only becomes perceptible when the essential oil is sufficiently freed from the intermediate compounds which generated it. Its formation is to some extent in inverse proportion to that of the tannin and colouring matters in the flower."

The above opinions (of Mesnard) are of course speculative.*

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* The subject has been investigated by other naturalists; amongst the most important records of their researches, the following may be referred to:—Guettard: "Sur les corps glanduleux des plantes," Mém. de l'Acad. Roy. des Sc. 1745 à 1756. De Mirbel: "Mém. sur l'anat. des plantes, et Eléments de physiol. vég. & de bot.," 1815. De Candolle: "Organogr. véget." Meyen: "Ueber die Secretions Organe der Pflænzen," Berlin, 1837. Ditto: "Neues System der Pflanzen-Physiologie," 1837. A. Weiss: "Die Pflanzenhaare. in Karsten's Botanische Untersuchungen," 1887. Martinet: "Organes de Sécrétion des végétaux. Thèse de la Faculté des Sciences Paris," 1871. Raw: "Enumeratio Rosarum," 1816.

THE art of distilling roses undoubtedly originated in Persia, and was practised on a large scale at a very remote date. The earliest record of this fact was discovered by Professor Flückiger in the National Library in Paris.* This document informs us, on the authority of Ibn Khaldun, that between the years 810 and 817 of the Christian era, during the reign of Kaliph Mamoun, the province of Faristan was required to pay an annual tribute of 30,000 bottles of rose water to the Treasury of Bagdad. It is also stated by Istakhri† that a considerable quantity of rose water was produced throughout Faristan, and was from thence sent to China,‡ India, Yemen, Egypt, Andalusia, and Magreb (in the Barbary States, especially to Morocco). The most important factories were at Dschur (now called Firuzabad), situate between Shiraz and the coast, and where, even to this day, the business is not altogether extinct.§

The art of distilling roses was probably introduced into Western countries by the Arabs. An important record concerning the early history of agricultural industries introduced by the Arabs into Spain ("le Calendrier d'Harib")|| recommends that the water, confection, syrup, and oil of roses, should be prepared in the month of April.

Throughout the Middle Ages, rose water constituted an important article of commerce between Eastern and Western countries. This fact is frequently alluded to in the writings of Joannes Actuarius,¶ physician at the Court of Constantinople towards the end of the twelfth century.

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* Notices et extraits des manuscrits de la Bibliothèque Impériale, xix., p. 364 (1862). † Le Livre des Compagnes, p. 73. ‡ A proof of the introduction by the Arabs of rose water into China, during the dynasty of Sung, is given in a work derived from Chinese sources, entitled, "On the knowledge possessed by the ancient Chinese of the Arabs and of the Arabian colonies, etc," by Bretschneider, London, 1871. § Flückiger, Pharmacognosie des Pflanzenreichs, 1883, p. 159. || Durean de la Malle, "Climatologie comparée de l'Italie et de l'Andalousie," Paris, 1849, p. 65; "Calendrier rural, etc., d'Harib;" Dozy, "Le Calendrier de Cordoue de l'année 961," Leyde, 1873. ¶ J. Actuarius, De Methodo Medendi, lib v. cap. iv. De Medicamentorum compositione; Basileæ, 1540, pp. 10, 19, 22, 31, etc.

In 1214, rose water is mentioned amongst other aromatics, such as Balsam of Mecca, camphor, etc., in a description of a fête given at Trévise.*

In 1379 "Rose water" appears on the Tariff List of the Custom House of the Port of Talamone, also in 1442 on the Custom's Registers of Florence, which had the control of that port.†

This industry was also carried on in Mesopotamia during the fourteenth century, the town of Nisibin situated west of the Tigris, between Mosul and Diarbekir having at that period a reputation for its rose water.‡

Kæmpfer, in his *Amœnitates*§ speaks with admiration of the roses of Shiraz, and of the extensive commerce dependent upon them. In point of fact, these celebrated rose plantations existed rather in the surrounding districts than in the town itself; he says: " . . . the rose and the vine flourish abundantly and with equal luxuriance, but not so much in the gardens in the interior of the town as in a suburb named Kesseri Desjt, or commonly called Mescidi Berdi, situate at the foot of a mountain towards the north-west, also in the gardens of the country people and peasants bordering the road between this suburb and the town. Although this region may have many equals as regards beauty of aspect, fertility of soil or perfection of climate, the fine products of its rose plantations and vineyards are unrivalled. Even as the roses in Persia are produced in greater abundance and with finer perfume than those in any other country in the world, so also do those of this particular district in the vicinity of Shiraz, excel in profusion and in fragrance those of any other locality in Persia."

The rose is not distinguished in Persia by any specific name, it is simply called *gul* (flower); that is to say, "*the* flower" par excellence. Its distilled water is transported to all parts of India, and is even sent into the other provinces of Persia for home use. It is much esteemed as an article of luxury at banquets and at festive meetings. It is used to sprinkle the guests on their arrival, as a sign of welcome, and flavoured with cinnamon and sweetened with white sugar it is taken as a beverage.*

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* "Cronica Paduana Rolandini" in Pertz Monumenta Germaniæ hist. scriptores, xix. p. 46. † Heyd. Levanthandel im Mittelalter, ii. p. 297. ‡ Voyage d'Ibn Batoutah, 1854, p. 140; trad. Defrémery. § Kæmpfer, Amœnitatum exoticarum, politico-physico-medicarum, fasc. v. quibus continentur variæ relationes, observationes, et descriptiones rerum Persicarum et ulterioris Asiæ, multa attentione, in peregrinationibus per universum Orientem, collectæ ab auctore, Lemgoviæ, 1712.

Kæmpfer does not give any description of the particular species of rose cultivated in these plantations. He gives a very detailed plan of the palace of Persepolis, and mentions the Garden of Roses *(rosetum)* or *Bagi Guldistuum* annexed to the building *Untsj mertébeh,* which extends in the form of an octagon, describing its dimensions, its central pavilion, its pictures and even its water cisterns, but makes no mention of its roses. Blondel says that the examination of specimens made by Olivier and Pissard during the present century, lead to the belief that the species cultivated was the *R. moschata.* The *R. Pissardi,* which, according to some botanists, is a distinct species, is a veritable *R. Moschata:* he adds that there exist at the present day living specimens of the Persian rose, and that they are cultivated by Godefroy-Lebœuf at Argenteuil, in France.†

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* Kæmpfer, Loc. cit., Fasc. ii. p. 373. † *R. moschata,* Miller, native of Barbary, is figured in Curtis' Botanical Magazine, t. 4,030, also by Lawrence, t. 64, in her work of illustrations from nature above-quoted ; also the double variety (fl. pleno) at t. 53 of the same. The *R. moschata Nepalensis* is figured in the Botanical Register, t. 829. Previous to the commencement of the sixteenth century writers on the subject of roses generally confused *R. moschata* with *R. Damascena,* and used either name indiscriminately. *R. Indica* (Lin. spec.) 705 is described and figured by Redoute, loc. cit. i. p. 51, t. 142 ; p. 35, t. 15. The *R. Indica odoratissima,* Lindl. Rosarum monographia, p. 106, Bot. Reg. t. 864, also a native of China, is the *R. odoratissima* of Sweet, and the *R. Indica fragrans* of Redoute, i. p. 6, t. 19 (this is noticed in "Gardiners' Chronicle," 1887, ii., p. 430). By crossing *R. Indica* with *R. moschata,* a French cultivator, P. Noisette, originated the "Noisette" roses, but the numerous varieties now in cultivation are mostly obtained by crossing the primitive "Noisette" with Tea-roses, so producing Hybrid Noisettes. By crossing *R. Indica* with *R. Damascena* the Bourbon rose (*Rosa Borbonica,* Redoute) was produced in 1819 ; and by crossing *R. Indica* with *R. Alpina* the Boursault Rose (*R. reclinata,* Redoute) resulted.

The original discovery of the possibility of separating the small drops of oily matter floating on the surface of rose water, appears to have been made by Geronimo Rossi at Ravenna, and this product is mentioned by Wecker in 1574[*] as "the Oil of Roses of Rubeus" (Rossi). The discovery was afterwards recorded by Rossi himself in his book published in 1582.[†] The essential oil of rose was next described by Porta in 1589,[‡] and in 1604 he writes: "Omnium difficillime extractionis est *rosarum oleum* atque in minimà quantitate sed *suavissimi odoris*."[§]

The druggists' price lists of the commencement of the seventeenth century, in Germany, quote both the *Oleum rosarum destillatum* and the *Oleum rosatum* (a rose-scented fixed oil), but the infinitely higher price of the former is sufficient to identify it as the volatile oil, or "otto."[||]

The next mention of this essential oil appears to be made by Angelus Sala, a writer in Germany during the period of from 1610 to 1630[¶] and then by Schrœder in 1649.[**] It is mentioned by Pomet, in his History of Drugs, 1694, as being well known in Paris at that date, but only obtainable in very small quantity and at a very high price. It was also described by Homberg in 1709 in a memoir entitled "Observations sur les huiles des plantes."[††]

It seems strange that although the rose is an oriental plant, and the art of distilling rose water was first practised in Persia, the otto of rose was known in Europe about forty years sooner than in the East, and that even then the discovery was made in Persia quite accidentally, and quite independently of any knowledge of the results attained by chemists in Western countries.

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[*] Wecker, "Antidotarium," published at Colmar, 1574. [†] Hyeronimi Rubei Ravennatis, "De Destillatione liber," Ravenna, 1582, Sect. ii. cap. xvi. p. 102. [‡] Porta, "Magie naturalis," lib. xx. [§] Porta, "De Destillatione," lib. ix. Roma, 1608. [||] "Documente zur Geschichte der Pharmacie," Halle, 1867, p. 37, by F. A. Flückiger; from which interesting work most of the above bibliographical references on this subject are taken. [¶] Angelus Sala, Opera medico-chymica, Francforti, 1647, p. 63-79. [**] Schrœder, Pharmacopœia medico-chymica, Ulm, 1649, lib. ii. cap. lxx. p. 241. [††] Mém. de l'Acad. Roy. des Sciences, p. 206.

The date of the discovery by the Persians of this valuable essence has been ascertained by Langlès to be 1612. He was thoroughly acquainted with the languages and literature of the East, and in his excellent little book* he shows that previous to this date (1612), no mention of otto of rose is made in any work written in Oriental language, and that the circumstances attending the discovery are for the first time described in a work written in Persian by Mohammed Achem, entitled *Tarykh montekheb lubâb*, which is a History of the Great Moguls from the year 1525 to 1667. In this work, mention of the essence is twice made. The first time, it occurs in the chapter entitled: "Marriage of the Princess Nour-Djihan with the habitant of the paradise Djihan-guyr; inventions and discoveries of the Queen of the World." The second mention is made in the chapter entitled: "History of the seventh year of the reign of Djihanguyr, and Feast of the New Year." According to the translation, it appears that at the commencement of this fête, the mother of Nour-Djihan having presented to the prince the "essence of rose water" which she had prepared, the prince thereon attached to this discovery his illustrious name, and called the perfume A'ther Djihan-guyry (Perfume of Djihanguyr); at the same time presenting to the princess a necklace of the value of 30,000 rupees.†

Another version of the circumstances connected with this discovery is recounted by Manucci, a Venetian physician who resided about forty years in India. He bases it on the "Annals of the Mongolian Empire," an important work translated and abstracted by Catron.* According to this description the fête was of a very costly and magnificent character, luxurious amusements of every sort being provided, the princess even carrying her extravagance and prodigality to the extent of causing rose water to flow through a canal constructed in the flower gardens. I then happened that whilst the emperor and the princess were walking along the bank of this canal they noticed that an oily stratum had concentrated on the rose water and was floating on its surface; this was carefully collected and recognised by the entire Court as the most delicate of perfumes. What thus resulted from accident was afterwards imitated by art.

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* L. Langès, Recherches sur la découverte de l'Essence de Roses, Paris, 1804. † Gladwin, in his "History of Hindustan, i. p. 201, a work based on authentic records, such as the *Maacer Djihanguyry* (Acts of Djihanguyr), by Kâmgar Hocein, and the Touzouk Djihanguyry (Commentaries of Djihanguyr) also attributes this discovery to the mother of the Empress Nour Djihan-Beygum, and in almost the same terms.

Whichever of these two narratives is really the most truthful, it seems to be an established fact that the manufacture of the otto in Persia dates from the period of this fête, viz., 1612. At the time of Kæmpfer's visit to Persia in 1684, the distilleries of Shiraz were in a most flourishing condition. He says,† "The roses of Shiraz are remarkable for yielding on distillation a fatty matter like butter, which is called *Aettr Gyl.* This substance is more valuable than gold, and nothing in the world possesses a perfume so agreeable and sweet; from this we may conclude that the rose growing in the country of Persepolis is of a strongly odoriferous nature." Kæmpfer also mentions the custom of blending the oil of santal with that of the rose (a practice which is perpetuated in India at the present day), and says: "The raspings of santal wood is sometimes added to the flowers previous to distillation. A century later (1787), this fact was confirmed by Archibald Keir,‡ who describes the primitive method of manufacture practised at Chatra in Ramgur The rose water prepared in this way (with santal wood), was sold separately, under the name of *Ssandàli Gulab.*§ Pure rose water, prepared by distilling roses alone with water is called

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* Manucci, Histoire générale de l'Empire Monghol depuis sa formation jusqu'à présent, 2 Ed. i. p. 326, 327. † Kæmpfer, Amœnitatum, etc., p. 373. ‡ Asiatic Researches, i. p. 309. § Zend-Avesta, i. Appendix, p. 525, 526 in Langlès, loc. cit.

Gulab. The word *Gul* in Persian (*Ouard* in Arabic), signifies in a general way "a flower," including also the idea of "perfume" or "perfumed flower," and is *particularly* applied to the rose (as before mentioned). The word *Athr, A'thr,* or *O'thr* is employed by the Arabs, the Turks, and the Persians to designate the essential oil of rose, even without the addition of the word *Gul,* but it is also applied to compound, or mixed perfumes, very much in the same way as the word *Abir,* which in Bombay is used to designate a compound of rose water, santal, violets, orange flower, musk and spikenard;—therefore *when pure otto of rose is solely and distinctly meant,* it is necessary to add the word *Gul* or Gyl after the word *Athr.*

At about the same period Forster[*] mentions the roses of Kashmir as being highly esteemed for their beauty, and adds that their "essence" is particularly valued. Colonel Polier, describing the manufacture of the otto,[†] says:—"In Kashmir they seldom use santal to adulterate the attar, but I have been informed that, to increase the quantity, they distil with the roses a sweet-scented grass, which does not communicate any unpleasant scent and gives the attar a clear green colour. This essence also does not congeal in a slight cold, as does that of roses."[‡]

At the commencement of the present century it is reported by Olivier[§] that he found the otto of rose industry in a highly prosperous condition at Shiraz, Faristan and Karman.

According to Forbes Watson,[||] Douglas,[¶] and Schlagenweit-Sakünlünski,[**] the cultivation of the rose and the art of distilling its flowers was introduced from Persia and Arabia into India, first to Kanauj, a town on the Ganges (which has now ceased to exist), and from thence to Ghazipur, Lahore, Armritsar and other localities in India, where this industry is still carried on, but the products are not more than sufficient for native requirements, and are not exported. According to Brandis* the species cultivated is the *R. Damascena.*

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[*] Voyages de l'Inde à St. Pétershourg, i. p. 294.

[†] Asiatic Researches, i. p. 332.

[‡] Here was evidently the origin of the wholesale adulterations afterwards practised in Bulgaria, and which, even now, the Bulgarian Government are quite unable to put a stop to.

[§] Voyage dans l'Empire Ottoman, 1807, v. p. 367.

[||] Catalogue of the Indian Department, Vienna Exhibition, 1873, p. 98.

[¶] Pharm. Journ. [i.] viii. p. 811.

[**] "Das genus Rosa in Hochasien, und über Rosenwasser und Rosenoel," in Buchner's Repertorium fur Pharmacie, xxiv. p. 129-143.

The Indian Method of Distillation

was described by Colonel Polier, of Lucknow, in 1787† as follows:—"About forty pounds of fresh roses (including the calyces, but with the stems cut close) are put into a still with sixty pounds of water, and distillation continued until thirty pounds of water come over, which is generally in about four or five hours. This rose water is distilled again with a fresh quantity (forty pounds) of roses and from fifteen to twenty pounds of rose water drawn over. This is poured into pans either of earthenware or tinned metal, and left exposed to the fresh air for the night. In the morning the otto is found swimming on the surface. It is then carefully skimmed off with a thin shell and poured into a small flask, and when the water and impurities have subsided it is decanted into another flask. The impurities and water are distilled again with fresh roses. The yield of otto is about one-and-a-half drachms from eighty pounds of roses, or, deducting the weight of the calyces, about three drachms per hundred pounds of rose leaves."

The process employed by the natives at Chatra in Ramgur, was described by Archibauld Keir.‡ He says the bodies of the stills are constructed of earthenware, which, absorbing the heat more gradually and slowly than metal, is less apt to communicate any empyreumatic odour by burning the contents. The head of the still, called by the natives the "*adkur*," is constructed like the head of an alembic, *i.e.*, with a channel running round its interior to collect the condensed product. The refrigeration takes place at the top of this head, which is of copper, a stream of water is kept pouring upon it, and is conducted away by a channel on the outside. [The writer of this description then expresses his opinion that this method of effecting the condensation is superior to the ordinary pipe or worm method, as the vapours being condensed as suddenly as they rise, the pressure on the liquid would be diminished, and therefore permit the water to boil at a lower degree of temperature than under ordinary atmospheric pressure. He appears to be the first observer who draws attention to the injurious effect of heat on essential oils, and to the desirability of diminishing as much as possible the time in which the oil is kept in contact with hot aqueous vapour.]

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* Forest Flora of North-Western and Central India, 1874, p. 200.
† Asiatic Researches, i. p. 332. ‡ Asiatic Researches, i. p. 309.

The requirements of Egypt, which are considerable, are supplied from Medinet Fayum, south-west of Cairo.

Although, as above proved, the discovery of otto of rose was made somewhat earlier in Europe than in Persia, yet, as a manufacturing industry, it was introduced by Turkey.

The oil was for some time distilled at Chio (Ollivier mentions that it was produced in that island in the year 1800), and probably at Smyrna.* It was also produced largely in the Barbary States, and especially in Tunis, where, according to a modern traveller,† the species cultivated was the *R. canina*, Lin. or a very odorous variety of it (thirty pounds of flowers yielding one-and-a-half drachm of oil)‡.

According to the accredited tradition, it was from Tunis, which had developed into one of the most important centres of this industry, that the culture was introduced, about two centuries ago into Bulgaria (then known as Eastern Roumelia), by a Turk. It is also a fact that the business was introduced and established in France (in Provence), from the coast of Africa.

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* Pharmacographia, p. 264. † Von Maltzan, Reise in den Regentschaften Tunis und Tripolis, Leipzig, 1870. ‡ Flückiger and Hanbury, Hist. des Drogues, i. p. 472.

At the present day the odorous products of the rose are extracted in Bulgaria, France, Germany, and to some extent in India, Persia, Tunis, Algeria, Morocco, and Egypt.

Having now traced the whole affair chronologically, we proceed to describe the cultivation, manufacture, etc., in Bulgaria, which is by far the most important producer (commercially considered) of the otto, and next France, which supplies the largest quantities of rose water, pommade, and "extrait." The German production is (as yet) on a smaller scale, but by reason of the more scientific processes adopted in cultivation and manipulation, its products are of a very superior kind.

The Rose Industry in Bulgaria.

The region devoted to the cultivation of roses south of the Balkans is situate in the northern portion of the province formerly known under the Turkish rule as Eastern Roumelia, and which is now included in Danubian Bulgaria. The acclimatisation of roses has been tried north of the Balkans, at Travna, but without success.

The rose country occupies especially the two valleys of the Toundja (canton of Kézanlik) and of the Strema (canton of Karlova) both bounded on the lower side by a spur of the Balkans called Sredna-Gora. The south side of this mountain supports numerous rose farms, but their produce is inferior to that obtained from the south side of the Balkans proper, not only in consequence of less favourable climatic and geological conditions, but because the two indispensable factors of the work of distillation, namely, the water, and the wood for fuel, are much less easy to obtain there by the distillers.

The two extreme points, longitudinally, of the rose cultivation are Koprivchtiza on the west, and Tvarditza on the east. These two villages are above 130 kilomètres distant one from the other.

The two principal centres of the industry are Karlova and (especially) Kézanlik, the finest quality of otto being produced in the mountainous zone which surrounds Kézanlik, not only by reason of its favourable southern aspect and specially suitable quality of soil, but also owing to the abundant flow of water during the harvest time, and the sufficiency of wood fuel obtainable on the spot.

The region of Kézanlik is situated about 400 mètres above the level of the sea. The climate is temperate, but very variable; the changes of temperature being frequent and singularly sudden. The thermometer falls in winter to — 20° C., and in summer reaches 40° C. The uncertainty of the weather at harvest time is a source of great anxiety to the cultivators. The mean temperature is nearly that of France, but sensibly colder than at Nice or Grasse (where the rose is largely cultivated). At Kézanlik, neither the orange, the olive, nor any of the plants indigenous to Provence are known to grow in the open air. The soil in the Kézanlik district is sandy, consequently very pervious to water. This condition is absolutely indispensable for the culture on a large scale. If the ground is calcarious or not sufficiently porous, or if a bed of clay lies at no great depth below the bed of sand and opposes the drainage of the waters by forming a basin, the roots soon decay. Hail-storms, too-prolonged drought, and late frosts, are very common occurrences, and terrible enemies to the growers.

The proximity of the mountains brings, however, frequent rains; besides which, the snows which accumulate on the summits during the winter, produce abundant subterranean waters, the origin of numerous springs.

The presence of water in a large quantity at harvest time is certainly one of the most important causes of the prosperity of the district of Kézanlik, from the point of view of rose growing. The town of Kézanlik itself is watered by several springs of more or less importance, tapped by canals and tunnels of an age long past, which feed numerous fountains, bringing water in abundance at harvest time to each grower. The surrounding villages are equally well irrigated. All the waters flow either into the river at Kézanlik, the Stara-Reka, or into other less important ones, and from there into the Toundjha. Even in times of the greatest drought water is never wanting in in this favoured region. From this, as may be imagined, results the relative inferiority of the villages south of the Sredna-Gora, where water is wanting, and where the streams dry up during the great heats which prevail, usually at the harvest season.

The rose cultivated in Bulgaria for the otto has been clearly identified by botanists as a variety of the *R. Damascena*, Miller, the red damask rose. It is distinguished from *R. centifolia* by the greater size of its spines, green bark, elongated fruit, and longer reflexed sepals. It forms a branching shrub which reaches the height of five or six feet, flowering in May and sometimes again in November. This second flowering is insignificant from an industrial point of view, but exemplifies the tendency which all the descendants of the *Rosa centifolia* have to revert to the original type. The branches, more or less spreading, spring from the base of the stem about the second year, and intermingling their sub-divisions form a very close thicket. The young shoots, from the time when they come above the ground till they have reached the height of twenty centimètres, are of a deep red colour. The branches, until they become old, are covered with brown, straight, and very closely set prickles or spines, which sometimes measure a centimètre in length. The leaves are from ten to fifteen centimètres in length, composed of seven folioles. The stipules are very wide, foliaceous, green, and prolonged to a sharp point. The median nerve is delicately velvet-like, and has numerous very small pedicellate glands mingled with the hairs. The folioles are unequal in size, elliptical, non-acuminate, and sharply serrate. The upper surface is smooth and bright green, the lower surface is of a dull glaucous colour, the margins and nerves being finely pubescent. The petiole is furnished with recurved spines and is clothed with short glandular brown hairs similar to those on the nerves. The odour of the stalk when bruised is very slight.

The flowers are grouped in two — or three — flowered cymes. The branches bear on the average seven flowers, and in good years as many as thirteen have been counted. The blooms are semi-double, and their diameter when full blown rarely exceeds four or five centimètres. The floral pedicels are about four centimètres long, and slender; they are armed with numerous very fine spines, mingled with glandulous hairs, which render the stalk very clammy and sticky to the touch. (The workmen who gather the flowers find that their fingers become hardened so that they do not feel the pricking of the thorns, but become covered with a dark resinous substance emanating from the glands of the flower stalks; the odour of this substance is strongly terebenaceous, and at the end of the day the men scrape the substance from their fingers, roll it into balls and keep it for mixing with tobacco in cigarettes.) The receptacle (seed vessel) is small, nearly conical and gradually diminishing to the thickness of the stalk, so blending with it; this also is full of resinous glands. The sepals are very pointed and often attain a length of three centimètres. The margins of the two outer sepals and the exterior margin of the partly exposed inner sepal of the unopened bud are provided with numerous very long, thin, tongue-like growths, covered with hispid glands on their outer surface. The two exposed sepals of the bud, and the exposed portion of the inner sepal are simply downy. The broad inner surface of the five sepals is covered at the lower part with a delicate pale down. The petals are orbicular, of a beautiful pink colour, almost red in the bud, but becoming paler after expansion. They are thin, not glossy, but not velvety. The pure white showing at their base gradually merges into the full colour of the petal. Their perfume is exquisite, very closely allied to that of *R. centifolia*, and is especially powerful at the moment of the opening of the bud. The stamens are few in number. The styles are slightly exsert, and free in their whole length. The colour of the berry is cherry red.

The most suitable ground for a rose plantation is that of a sandy, porous nature, allowing of free percolation of moisture, and sloping towards the south so as to be sheltered from the cold winds of winter. (Abundance of running water in the vicinity is absolutely necessary, as has already been pointed out.) Many of the grounds in Bulgaria which *apparently* possess the advantage of shelter by being situate on the southern slope of a mountain really are at a greater disadvantage than if situate in the middle of a plain, for the rose is indeed a delicate plant, very sensitive to atmospheric extremes at certain critical epochs of its existence, particularly at the time of its budding; thus, a white frost in April is very disastrous. Unseasonable rain, which on neighbouring high peaks easily turns to snow, suffices to effect this; the next morning a rapid clearing of the sky brings the frost, and the crop is severely damaged. What the rose needs at this critical period is a warm sun, alternating with showers. Consular Report No. 1,300 states that owing to untimely rains just before the harvest the 1892 yield of otto in Bulgaria was very small, amounting only to 1,300 kilos.

The 1893 rose crop in Bulgaria was nearly three weeks late, and fears were naturally entertained of a diminished yield, owing to the distillation taking place in a hotter period of the year than usual. But contrary to all custom, cool weather, accompanied by frequent rain showers, set in during the first days of June, when the distillation was just commencing, and the flowers developed in such abundance, that, in spite of the damage caused by the early spring frosts, the crop turned out fully an average one, the otto production of the season amounting to 1,835 kilos.

It may be added that early and excessive droughts are not less prejudicial to rose trees than are rains followed by frost Besides the fact that this dryness retards the usual evolution of the rose tree, it facilitates the premature development of one of the most dangerous parasites of the plant, the tchervey (Turkish for mite or maggot), a sort of larva, born in the spring, which intrudes itself under the bark of the young branches, describing an annular circuit round the wood. Outwardly, nothing reveals its presence but a slight swelling on the surface of the epidermis. But from that time the branch rapidly withers away, and if one happens to touch it with the finger, it breaks off dry like dead wood.

It will thus be seen that the climate in the rose districts south of the Balkans is very uncertain, and considering the very valuable and profitable nature of the crop, it is advisable to seek elsewhere a convenient locality for establishing such plantations. Such localities possessing the requisite conditions of soil, aspect, temperature and reliably uniform climate could doubtless be found in many countries, notwithstanding the very misleading statements made by Bulgarian distillers and merchants in their trade circulars,* statements which are, of course, made to guard their monopoly and deter enterprising competitors from estabing this industry elsewhere.

In Bulgaria the rose bushes are planted close together, so as to form compact hedges, in rows sometimes 100 yards long. The bushes grow six or seven feet high. A clear space of six feet is left between each row. This distance, now maintained between the bushes, used to be smaller ; its width then merely allowed two people to walk through. All the necessary work for the cultivation was done by hand. Now it is preferred, in order to economise manual labour, to plough by means of oxen, and the saving thus effected largely compensates for the loss of productive ground which it necessitates.

The propagation is not effected by cuttings or layers, but by cutting down or digging up entire bushes, such as appear to leave blanks in the lines of flower in the hedgerows by reason of the plants being worn out. These bushes are pulled completely up and chopped into pieces. As the branches spring from the bottom of the stem, the stump, with as much of the root as possible left attached, is torn up and divided with a spade or hatchet, and is placed with the boughs, leaves and all, in pieces four or five abreast horizontally in long, straight trenches about forty centimètres broad and the same in depth; part of the mould taken from the trench is then thrown lightly on, and a thin dressing of manure is thrown over all. If possible it is then watered. The planting is done in October or November; the young shoots make their appearance about the following April, being of a deep red colour until they attain the height of about twenty centimètres. The ground is then weeded and raked with great care; it is again weeded in the middle of June, and in November, when the rest of the mould which was not put back into the trench the year before, is carefully heaped up to the base of the young shoots (which by this time are about thirty centimètres high), to protect them against the cold of winter. The following May the plants will have attained the height of about sixty centimètres, and produce a few flowers which will be harvested with the rest, and be sufficiently productive to cover the expenses incurred in keeping the ground clean. The next year they will be in full bearing. The maximum production is in the fifth year. When the bush has attained its tenth year, many cultivators prune it right down to the ground to strengthen it; new branches and even flowers will appear the following year. The harvest commences about the third week in May, according to the season, and lasts about a month; there is sometimes another small gathering of flowers in November. After the harvest the ground is cleaned of weeds, and in October it is slightly manured, the earth being hoed up to the roots of the bushes to protect them in the winter. The pruning takes place in March, when all withered branches are carefully removed. This operation is done with the help of an apparatus of antique simplicity. The workman uses two sticks, one of which he holds in each hand. That in the left hand is bifurcated like a Y at its end, and serves to hold firmly the branch that he wishes to remove. The other stick, held in the right hand, ends in a little sickle, which is very sharp, by the help of which the workman cuts off the branch by sliding the blade along the bifurcated stick.

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* *Vide* the "World's Fair" circular of Shipkoff and Co., Kézanlik ; reproduced in *The Manufacturing Chemist*, 20th January, 1894.

These dry branches form a considerable amount of waste, which is collected in lines along the edges of the field, on the inner side of the ditch which bounds it, to prevent the depredations of cattle moving along the roads.

In April the lanes are again ploughed, the winter's mould about the foot of the rose trees is again levelled with the rake, and, lastly, some days before the blowing time, which begins between May 20th and June 1st, it is well to plough for a last time, and to turn up the earth about the bushes. This ploughing is, as before mentioned, effected by means of a plough with a yoke of two oxen, and it is customary to work four furrows to each lane. One ox is placed in each of two adjoining lanes, the bar on their horns being carried above the branches, which it may, nevertheless, easily bend without inconvenience. Then the weeds are pulled up. This operation should be conducted with great care. It is generally confided to women, who then receive for salary about 6d. a day when they are fed by the proprietor, and about 10d. (one lef) when they are not.

The question of watering is much disputed. Water obviously favours the development and production of the rose tree, but it is a known fact that trees which have received no water but the rains are more hardy than others, and, at springtime, much less sensitive than these latter to the baneful effects of hoar frost.

As the bushes grow older, the branches, which are more or less spreading and spring from the bottom of the stem, interlace and form a very close thicket. The life of the bush exceeds twenty years if carefully tended, but the care required is unceasing; the ground must be hoed or ploughed at least four times during the year and kept scrupulously clean of weeds, in fact the whole principle which governs this mode of cultivation may be summed up as follows:—"Be careful to remove weeds and withered branches, and as often as possible turn up the ground in which the trees are growing." The climatic conditions which affect the vigour of the tree have already been described, but it may briefly be repeated that in very cold winters the branches die; frost and fog are very injurious, especially if occurring when the sap is rising. The quality of the crop depends greatly on the temperature during the harvest; if during that time the weather be cold and wet, the flowers will develop very slowly, and a very great heat expands them too quickly.

The borders of the Bulgarian plantations are defined by hedges of a white rose, the *Rosa alba*, L. It is a bush of more vigorous growth than the *R. Damascena*, and flowers about a fortnight later. Its odour is agreeable, but much inferior to that of the red rose. The oil derived from it is of very poor quality, but it is rich in stereoptene, and unscrupulous manufacturers distil its flowers with those of the red, in order that the otto of the latter may bear adulteration with a larger proportion of "geranium oil."

The harvest is most rapid in hot summers. In a fortnight all the trees are in flower. If the temperature is lower and the rains more frequent, the flowers appear in succession, and the harvest may be prolonged for a whole month. This latter circumstance is the most favourable that a proprietor can desire. With an equal yield, the years in which the crop comes thus slowly, give much more satisfactory results than those years in which the flowering is more quickly completed. Thus, for example, on a hectare of land (nearly two-and-a-half acres), producing, say three kilos of flowers (which is the average yield), if the crop lasts thirty days, about one hundred kilos of flowers will be ready for plucking every morning, and if the harvest lasts only fifteen days there are two hundred kilos to gather and distil in the same time with the same staff of workmen and the same stock of tools and utensils. One thus sees the inconvenience which results, namely, the too long duration of the daily gathering, which is prolonged until the afternoon, causing deterioration of the flowers by loss of fragrance, partial decomposition by fermentation of the flowers lying in heaps during the heat of the day, obstruction at the distilleries by reason of the insufficient size of the stills, and even the impossibility of distilling the entire quantity gathered on the same day. Under these adverse conditions all the work is badly done, and the quality of the product suffers. Therefore, to be able to call a harvest good, one must take into account not only the gross quantity of flowers expanded, but the time that their progressive expansion has lasted.

The large growers employ women to gather the flowers and pay them at the rate of two centimes per kilo. The peasants gather the produce of their own field, aided by their wives and children.

The harvest begins at dawn, whatever weather prevails. The harvesters pass from lane to lane and pick every flower opened and every half opened bud, as these, if not gathered, would open completely in the course of the day, and would be faded ere the next.

The flowers, picked by hand, are thrown just as they are, that is to say, including their green parts, into a large basket carried on the left arm of the harvester, or simply into her apron. The contents of these baskets are afterwards collected together in sacks which hold from thirty to forty kilos. It is estimated that on the average, one thousand roses go to a kilo, and a hectare of land produces three million flowers, and these yield at most one kilo of otto.

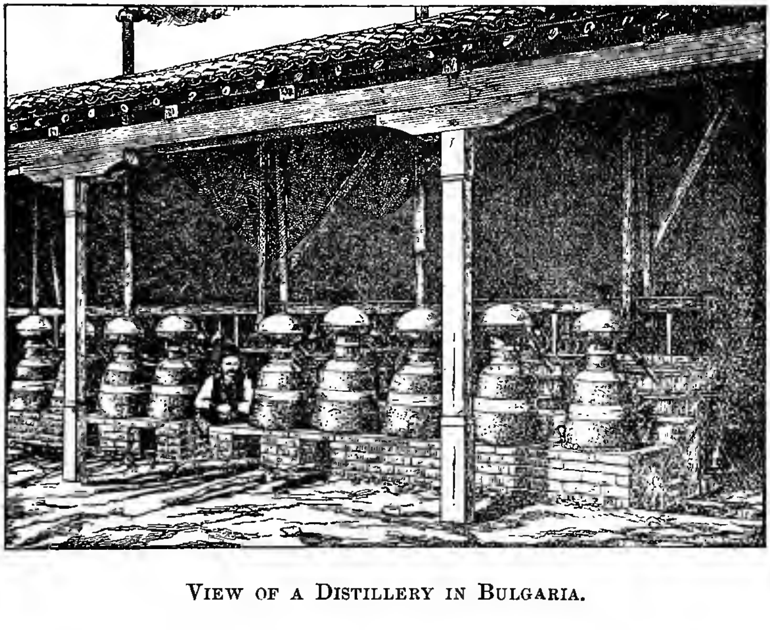
In periods of great heat, when the efflorescence is very rapid, and the men are compelled to continue gathering till noon, and even later, the flowers have a very feeble scent, and yield a much smaller quantity of otto.

The sacks are carried to the distillery from time to time, as they are full; but there is often much delay in this.

Some of the peasants not being able, for want of capital, and more often for want of water, to distil their own crops, sell them on the spot to another trader, or may have already sold them in advance. In these cases fifteen to eighteen centimes (according to the village), is paid per kilo of gathered flowers. White roses are vended separately when they occur in any quantity, or if mixed with the red a reduction of as much as three centimes may be made in the price.

The stills are built under rough sheds, open on one side, and are arranged in a row. Water is brought by a wooden gutter fixed to the roof, and passing above the cooling tubs permits a stream of water to flow into each, by a special opening.

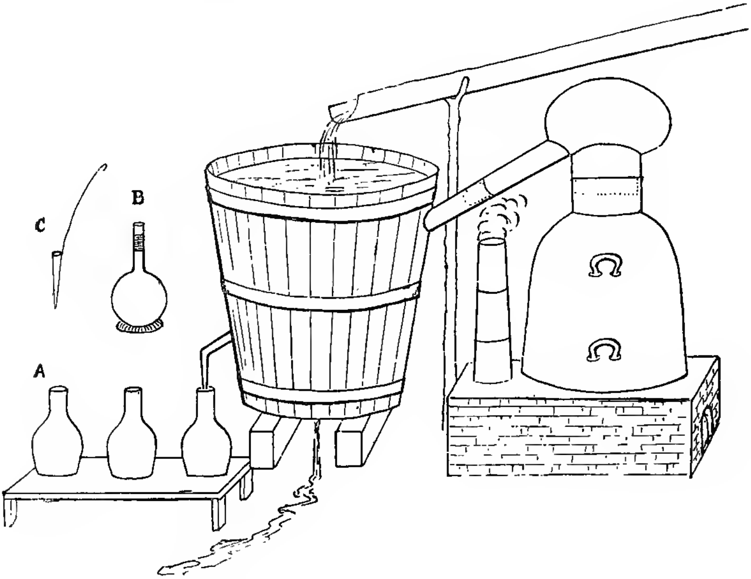
In some places, the proprietors of mills situated above a watercourse, have large sheds of this kind made, which they hire out to the peasants during distilling time, at the rate of four francs per still, water included, and under which, during the bad season, they shelter cattle.



View of a Distillery in Bulgaria.

The peasants' distilleries are constructed in a more temporary way; the greater number being only put up at harvest time. These are merely thatched sheds and are seldom supported by a brick wall at the back.

Villages too distant from rivers or streams are reduced to selling their harvests to a more fortunately situated neighbour, or to have their sacks of flowers carried as best they can to the nearest stream, on the banks of which they put up their distilling apparatus. Some manage to construct a canal communication. which brings water to them from the river; others, situated too high up, construct elevator wheels provided with a system of cups, which enable them to obtain the necessary supply. Sometimes they have recourse to the water from wells. But much more often the peasant prefers to avoid all this trouble, by selling his harvest; and in this case it is nearly always bespoken beforehand, the merchant being at the same time, more or less, the banker.



The annexed sketch representing the rough distillatory apparatus used in Bulgaria is copied from one drawn by a Turkish engineer, and published in a Consular Report in 1872. It appears to agree with a sketch recently published by Christo Christoff, of Kézanlik, of the apparatus actually in use at the present day. The difference in shape is very trifling.

The still is of sheet copper, in the shape of a truncated cone. The body of it is about forty-three inches in height, composed of two superposed pieces joined at about the middle by a tinned band.

The diameter of the body at the level of this band is about thirty-two inches. The diameter of the neck is about ten inches. The head is a very peculiar shape, somewhat resembling the top of a mushroom. It is thirteen inches high, and made of two pieces soldered together. The interior surfaces are tinned. A narrow tube bending downwards is soldered into the lower part and connects it with the condenser, which is simply a straight tin tube, about forty-nine inches long, passing obliquely through a wooden tub of about thirty-nine inches diameter at the top. The cold water for condensation is supplied by a wooden gutter suspended over the condenser. There is a hole at the bottom of the condensing tub, into which an upright pipe is fixed; the upper end of this pipe reaches nearly to the top of the tub. This allows for the overflow of the hot water, which runs away on the ground.

The different parts of the apparatus are made at Kézanlik. The still is priced according to weight.

The operation is conducted in the following way:—Into the body of the still (which is about 110 litres capacity) a charge of ten kilos of flowers, just as they are gathered, that is to say, including the green parts, is let in by means of a sort of wicker funnel, and seventy-five litres of water added. The separate parts of the still are then adjusted together, and the joints luted with strips of cotton about two inches wide, moistened with wet clay. The furnace is next lit, and the water in the apparatus brought rapidly to the boiling point, the fire is then allowed gradually to moderate. The fuel consists of long pieces of wood, which the workpeople do not trouble to saw, and which, lighted at one end, are pushed into the furnace as fast as the end is consumed, and of course to lower the fire, or put it out altogether, it is only necessary to pull out the wood by the unburnt end. There is no door to the furnace, and the smoke escapes by a short piece of pipe stuck in the brickwork. The guide, or index for the regulation of the fire, is the nature and condition of the distillate. Above all, it is necessary to avoid the escape of steam at the end of the condensing tube; this would show imperfect condensation and loss of oil.

This extremely primitive operation lasts about an hour and a half, and should be stopped when ten litres of liquid have distilled over; this has been received in two flasks of five litres each, which are placed at once along the wall of the shed, on a shelf put there for that purpose. The apparatus is then disconnected, and its contents emptied on to a sieve. The exhausted petals are thrown away, and the residual water from the still being warm is returned to the still for another distillation with fresh flowers, with the short-sighted idea of economising a certain quantity of fuel, and regardless of the fact that this foul water is injurious to the delicate perfume of the next charge. The still is then re-charged with fresh flowers, the necessary quantity of water added, and the work recommences.

This operation is repeated until all the flowers gathered in the morning have been distilled, even though work continue till night. Flowers distilled after twenty-four hours' delay have not only lost much of their perfume, but the yield is of very inferior quality, owing to the products of fermentation; some endeavours are made, although unsuccessfully, to check the deteriorating effects of delay; thus, when the sacks accumulate in too great numbers, and would have to remain some time in the distillery before their contents could be used, the flowers are spread out in the shade on the ground, in a cool place, stable or cellar, or even, when they are in a low country, at the side of the river, in very low pitched huts, covered with branches, and constructed for this purpose.

The two flasks of rose water above mentioned contain all the otto obtainable from the ten kilos of flowers, yet some distillers continue the operation until they have obtained three flasks of distillate, making fifteen litres in all. The result is not improved in quality, but the distillers wrongly believe that it contains more stereoptene, and so permits of a larger adulteration with "geranium" without the fraud being detected. The next step is to draw from the rose water the otto which it contains. For this a second distillation is made, mixing in one still the produce of the first distillation of four stills, that is to say, eight flasks, or forty litres. The distillation is conducted as before, but only five litres of distillate are collected, the water remaining in the still being reserved for fresh flowers. The flasks which receive the first distillate are bell shaped, with short necks, marked A in the figure (page 42); they measure about forty centimètres in height, with a diameter of twenty-five centimètres at their base. The flask which receives the product of the second distillation is globe shaped, with a long neck, like a laboratory boiling flask, Figure B. The neck is twenty centimètres high, and four centimètres wide; the entire height of the flask is about forty centimètres. This is made of thin Hungarian glass. Its capacity is also five litres. This second distillate (five litres) is at first white and cloudy like an emulsion, but on cooling, it gradually clears and the oil rises to the surface in the narrow neck, forming a stratum of from two to four millimètres in depth. It is removed by a sort of funnel-shaped spoon C, made of tin; the bowl is a simple inverted cone, eight centimètres deep and two centimètres broad, pierced at its lower extremity by a very small hole. The small diameter of the bowl allows of its easy introduction into the narrow neck of the flask. It is plunged below the oily layer, and at once brought up, carefully but quickly. Each time it brings up a portion of the oily stratum, with a small quantity of water. This latter, being the heavier, goes to the bottom, and escapes through the hole, falling back into the flask. The moment all the water has run out, and when the otto would pass in its turn, the contents of the bowl are quickly poured into the collecting flasks. These collecting flasks, which are almost the same throughout the otto of rose trade in Bulgaria, hold either four hundred grammes or one kilogramme of otto. They are of strong glass, sometimes shaped with facets, and closed by a glass stopper, ground to fit accurately. For exportation, the otto is put into round copper bottles, flat at the sides, and sewn over with felt.

A more barbarous process of treating a flower so delicate and so exquisitely fine, can scarcely be conceived. The oil so manufactured is scorched and empyreumatic in odour, and is *very* far from conveying to the mind anything like a true idea of the pure, natural perfume. It is probable that after some days the water in the still, which has already served for a number of distillations, contains a large quantity of salts and resinous matters, which raises its boiling point considerably above 100° C., a temperature which the oil cannot stand without undergoing a change which is deleterious to its character. There can be no doubt that the less heat it is subjected to, the truer and finer the result, and to attain this the body of the still should be uniformly heated by a steam jacket or by a steam coil in its body protected from contact with the flowers; also the boiling point should be lowered by reducing the atmospheric pressure, *i.e.*, working under a partial vacuum. In this way the particles of oil could be evaporated very rapidly, and at a low temperature. It may further be observed that the less time the oil remains in a state of vapour the better, and for this purpose the rapidity of refrigeration in the condenser is very important. Of course, by surrounding the condenser with a freezing mixture, or by maintaining it by any of the ordinary methods of congelation at a very low temperature, the condensing tube (if narrow) would be apt to become choked with stereoptene, but to avoid this, a condenser with broad flat surfaces could be employed.

A small specimen of a green coloured otto was prepared at Kézanlik as a sample for the exhibition at Philipopolis. It was stated to be the first running of the distillate, which separates mechanically *before the oily water is redistilled.* Its odour was particularly exquisite, resembling fine French or German otto. Its melting point was 25° C., and it yielded the unusual proportion of 63·7 per cent. of stereoptene. This latter circumstance is explained by the fact that stereoptene being insoluble in water, always goes over with the first runnings of oil, and separates upon the surface of the water. In Bulgaria, this first distillate is afterwards mixed with the other distillate and redistilled, so merging it into the ordinary yellow oil. These facts prove that the quality of otto of rose is much injured by the re-distillation of the oily water over an open fire, which is the common Bulgarian practice. The ordinary Bulgarian yellow otto of rose cannot be compared, for delicacy of aroma, with the first green distillate above mentioned. From these facts we may infer that with a more rational process of harvesting and distillation, the Bulgarian flowers could be made to yield an otto of fine quality, and that anyone who, in a reforming spirit, would have the discrimination to break with the old traditions of manufacture, would obtain control of the market of this article.

Yet, apart from this consideration of coarse method of manufacture, the oil is submitted to further mutilation by the admitted wholesale adulteration with the so called "geranium" oil, an oil which is itself often adulterated to the amount of fifty per cent., as hereafter explained. Formerly, this adulteration was only done in Constantinople, from whence, it may be said, that not even a single gramme of pure otto was ever exported. It afterwards became usual to perform the adulteration in Bulgaria, either by the distiller himself, who mixes the two ottos directly, or sprinkles his roses with otto of geranium before distilling them, so that the vapour of the two may mix completely during the operation, and make a more uniform blend, and to a great extent mask the odour of geranium, or it is perpetrated by the merchant who buys up the oil from the distillers.

These facts naturally brought the Bulgarian oil into great disrepute, and the stigma still remains, notwithstanding the efforts of the Bulgarian Government. A pure oriental oil can now only be bought through the most reliable wholesale dealers, such as Messrs. Schimmel and Co., of Leipzig, who have agents in Bulgaria, and test the parcels they receive therefrom; however, their Bulgarian import is vastly inferior to the otto of their own distillation from roses of their own growth, as hereafter explained.

The importance of the yield from the different villages in each rose growing district in Bulgaria may be estimated by the following totals of each village in each canton for the years 1891 and 1892.*

I—CANTON OF KÉZANLIK.

LOCALITY.	1892.		1891.	
	KILOS.	GRAMS.	KILOS.	GRAMS.
Kézanlik	25	—	34	—
Alexandrovo	12	—	21	—
Domouchlare	8	—	10	—
Malco-Selo	3	500	7	—
Gomelo-Selo	48	—	27	—
Sophilare..	11	—	4	—
Tarnitchane	8	—	3	—
Toria	17	500	21	—
Gabarevo..	5	500	7	—
Bania	18	—	27	—
Karaghitli	6	—	9	—
Simitleri	8	—	17	—
Kazalajdere	13	—	17	500
Armaganovo	5	—	8	—
Orozovo	6	—	9	—
Ichiklie	3	—	4	—
Rajina	6	—	8	—
Urenlie	3	—	6	500
Gorne-Sahrane	7	—	10	—
Dolne-Sahrane	2	—	4	—
Bitchirli	2	500	3	—
Imitli	10	—	17	—
Cheïnovo	11	—	16	—
Chipka	23	—	31	—
Sikiretchevo	2	—	3	—
Saltacovo	3	—	6	—
Assa	7	—	12	—
Enina	38	—	55	—
Gussovo	3	—	7	—
Carried over	315	--	404	-

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* These statistics were personally collected by the agent of Messrs. Schimmel and Co.

I—Canton of Kézanlik (continued).

Locality.	1892.		1891.	
	Kilos.	Grams.	Kilos.	Grams.
Brought over	315	—	404	—
Maglich	32	—	50	—
Toulovo-Selo	3	—	5	—
Imichleri	5	—	7	—
Dolne-Soufilare	1	—	2	—
Ekanlie	22	—	23	—
Kachlata	5	500	8	—
Lahanlie	13	—	22	—
Elhovo	31	—	42	—
Kozloudja	10	—	17	—
Tchanaktchi	3	—	5	—
Seltzi	2	—	3	—
Kovanlaka	16	—	28	—
	458	500	616	

II—Canton of Strema (Karlovo).

Locality.	1892.		1891.	
	Kilos	Grams.	Kilos.	Grams.
Karlova	20	—	28	—
Klissoura	110	—	60	—
Rahmanlaré	48	—	60	—
Teketo	17	—	25	—
Zlatina	14	—	22	—
Karnare	4	—	7	—
Karásarli	7	—	12	—
Carried over	220	—	214	—

II—Canton of Strema (Karlovo) (continued).

Locality.	1892.		1891.	
	Kilos.	Grams.	Kilos.	Grams.
Brought over	220	—	214	—
Derili	23	—	30	—
Oktchoulare	13	—	16	—
Voïnagovo	15	—	26	—
Dabini	17	—	26	—
Aïganovo	6	—	13	—
Aïevo	2	—	3	—
Sopot	12	—	18	—
Tatarito	3	—	5	—
Achaklaré	3	500	6	—
Isar-Kusseleri	8	—	12	—
Mihiltzi	9	—	11	—
Tchoukourli	4	500	6	—
Korou-Imitli	2	—	5	—
Davoudjova	2	—	3	—
Isara	2	—	4	500
Dimirdjileri	2	—	4	—
Bania	2	500	5	—
Madjeri	5	—	12	—
Bogaza	9	—	20	—
Dolne-Omarobasse	17	—	27	—
Gorne-Omarobasse	4	—	7	—
Kourtovo	3	—	7	—
Mitirisovo	20	—	26	—
Arapovo	6	—	13	—
Kalofer	21	—	23	—
Dovoundji	1	—	2	—
Kusseleri	15	—	26	—
Guilleri	15	500	22	—
Koutchmalare	2	—	3	—
	465		595	500

III—CANTON OF SARNAGORA (BREZOVO).

LOCALITY.	1892.		1891.	
	KILOS.	GRAMS.	KILOS.	GRAMS.
Adjar	20	—	25	—
Mratchenic	7	—	10	—
Karadja	5	—	8	—
Mousloutchan	7	—	11	—
Sara-Dimirdjileri ..	4	—	7	—
Doundouocvo	3	—	6	—
Kadarechikli	1	—	2	—
Sakarli	3	—	5	—
Rahmanli	50	—	63	—
Hamzalari	22	—	27	—
Kolatchovo	9	—	13	—
Tchalari	6	—	10	—
Baldjalari	7	—	10	—
Babek	4	500	8	—
	148	500	205	—

IV—CANTON OF STARA ZAGORA.

LOCALITY.	1892.		1891.	
	KILOS.	GRAMS.	KILOS.	GRAMS.
Dalboki	6	—	8	—
Orehovitza	5	—	7	—
Kolana	3	—	6	—
Novo-Mahala	3	—	5	—
Derventa	7	—	8	—
Balachli	3	—	5	—
Richteni	4	—	5	—
Kazanka	9	—	11	—
Ada-Tepe	2	—	3	—
	42	—	58	—

V—CANTON OF OVTCHEHLIN.

LOCALITY.	1892.		1891.	
	KILOS.	GRAMS.	KILOS.	GRAMS.
Koprivchtiza . . .	3	—	5	—
Doudinie	3	—	5	—
Panagurichte	6	—	9	—
St. Novo Solo	7	—	13	—
Zindjirli	8	—	10	—
Panitcheri	11	—	17	—
	38	—	59	—

VI—CANTON OF NOVA ZAGORA.

LOCALITY.	1892.		1891.	
	KILOS.	GRAMS.	KILOS.	GRAMS.
Tvardiza	4	—	6	—
Kososmadi	3	—	5	—
Konari	7	—	10	—
Hainto	6	—	9	—
Nicolaevo..	4	—	6	—
Zapatna	4	—	5	—
Dolno-Achanakchi ..	6	—	7	—
Balabanli ..	2	—	3	—
	36	—	51	—

VII—CANTON OF TCHIRPAN.

LOCALITY.	1892.		1891.	
	KILOS.	GRAMS.	KILOS.	GRAMS.
Jenicher	11	—	23	—
Konouptchi	4	—	7	—
Alagune	12	—	16	—
Karadjoven	1	500	2	—
Cheker-Bounar	1	—	1	500
Evdjileri	3	—	4	—
Kalfata	1	—	2	—
	33	500	55	500

VIII—CANTON OF PECHTERA.

LOCALITY.	1892.		1891.	
	KILOS.	GRAMS.	KILOS.	GRAMS.
Bratzigovo	70	—	50	—
Kouzarovo	8	—	10	—
Pechtera	11	—	19	—
	89	—	79	—

SUMMARY.

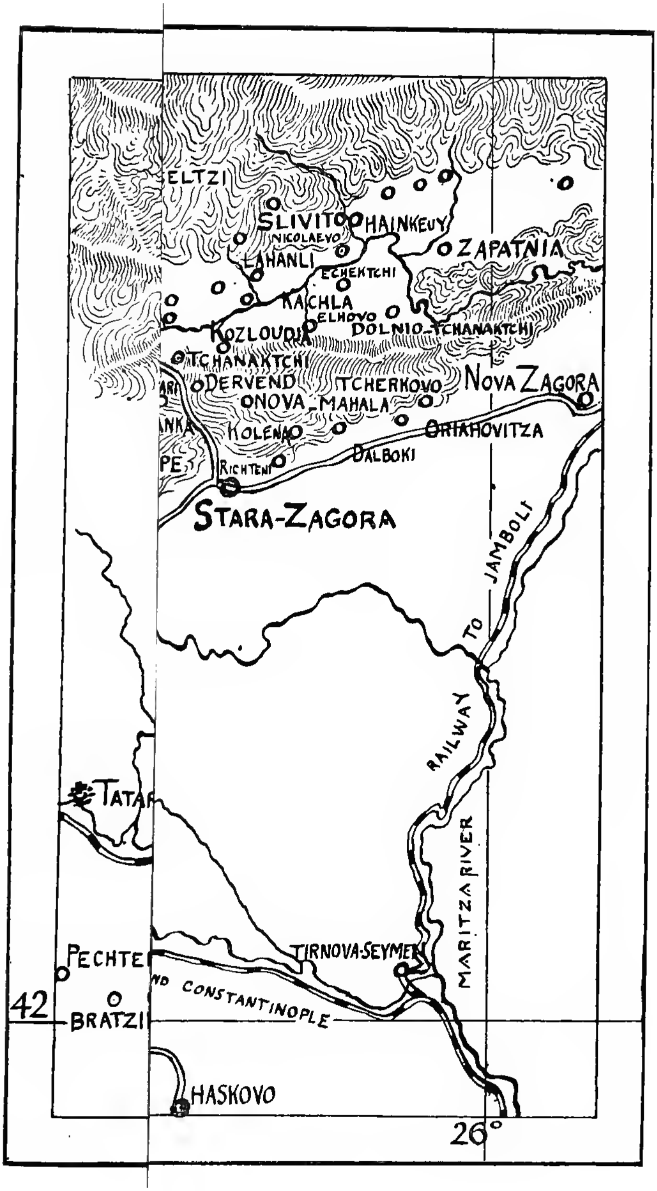
			1891.	1892.	1893.
I.—	Canton of	Kézanlik	616	458	765.500
II.	,,	Strema (Karlovo)	595.500	465	569
III.	,,	Sarnagora (Brezovo)	205	148.500	169.500
IV.	,,	Stara-Zagora	58	42	56.500
V.	,,	Ovtchehlin	59	38	50
VI.	,,	Nova Zagora	51	36	74.500
VII.	,,	Tchirpan	55.500	33.500	49
VIII.	,,	Pechtera	79	89	101
		Total	1719 kilos.	1310 kilos.	1835 kilos.

The extremely unsatisfactory result of the 1892 crop was due to the lateness of the harvest, which commenced only on the 4th June. To effect a favourable result, the quantity of flowers is of less importance than cool moist weather, which is above all things necessary, so that the blossoms open slowly and remain fresh. In 1892 these factors failed completely. The flowers were developed so rapidly by the heat that the perfume suffered by it, and a great part had to be left to wither. The distillation, which under normal conditions occupies twenty to twenty-five days, was consequently completed in twelve to fifteen days, and resulted in a considerable deficit as compared with previous years.

As regards the crop of 1894, the figures are not yet officially stated, but it is believed that the yield of oil is from six to seven per cent. more than in 1893.*

The following is a summary of the quantities of flowers manipulated in the last three years, and the number of stills employed:

* *The Manufacturing Chemist*, 18th August, 1894.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KACHLA
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DOLNIO-TCHANAKTCHI
KOZLOUDJA
TCHANAKTCHI
DERVEND
TCHERKOVO
NOVA ZAGORA
NOVA-MAHALA
ARI
ANKA
KOLENA
ORIAHOVITZA
DALBOKI
PE
RICHTENI
STARA-ZAGORA
RAILWAY TO JAMBOLI
MARITZA RIVER
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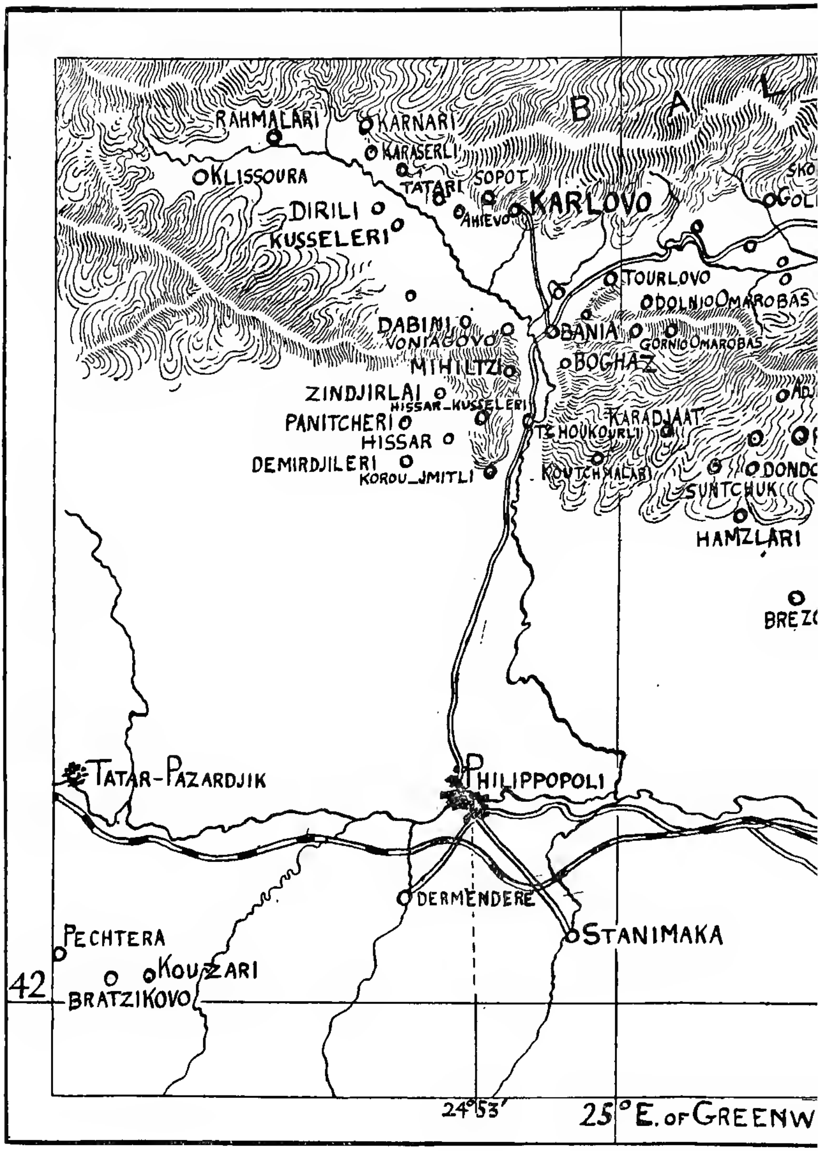
TIRNOVA-SEYMEN
ND CONSTANTINOPLE
42
BRATZI
HASKOVO
26°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KUSSELERI
TOURLOVO
DOLNIO OMAROBAS
DABINI
VONIAGOVO
BANIA
GORNIO OMAROBAS
MIHILTZI
BOGHAZ
ZINDJIRLAI
HISSAR_KUSSELERI
KARADJAAT
PANITCHERI
TCHOUKOURLI
HISSAR
DEMIRDJILERI
KOROU_JMITLI
KOUTCHMALAR
SUNTCHUK
DONDO
HAMZLARI
BREZO
TATAR-PAZARDJIK
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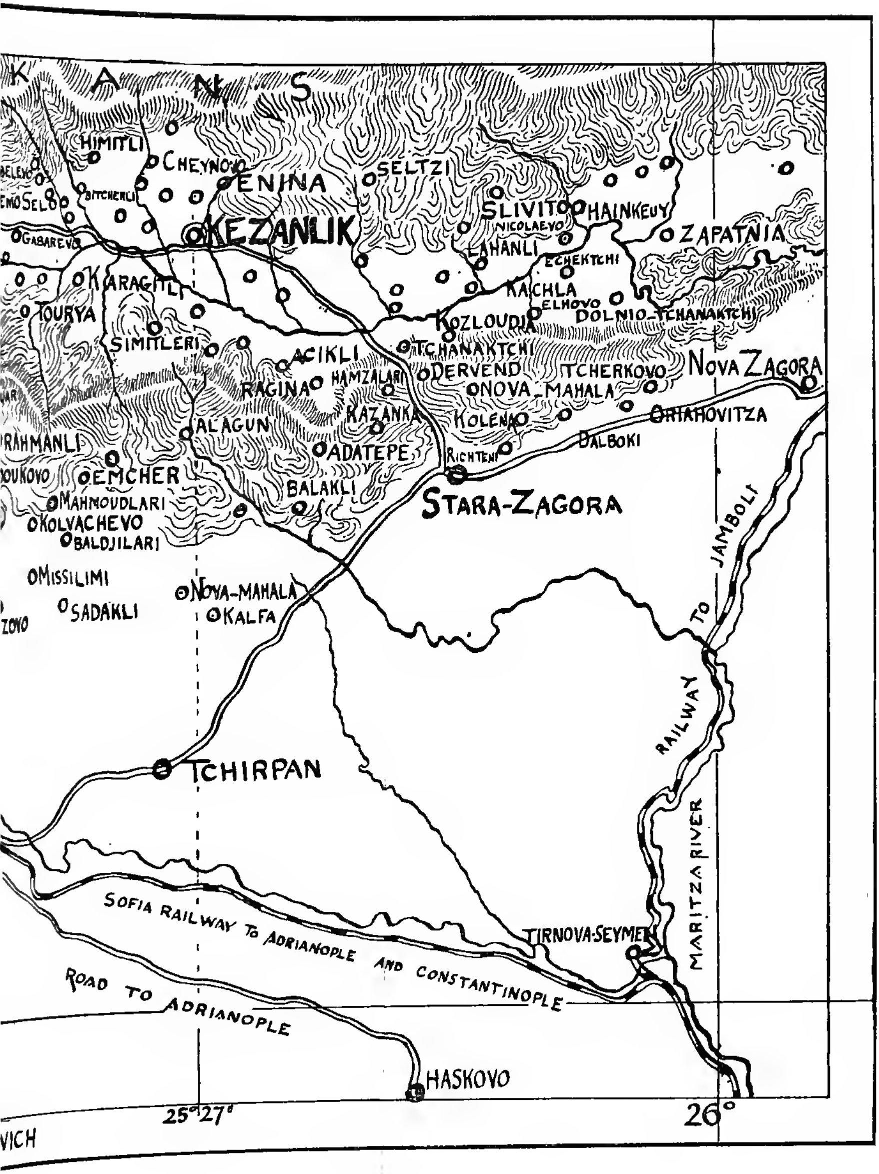

KANS
HIMITLI
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ZAPATNIA
LAHANLI
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KACHLA
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DOLNIO-TCHANAKTCHI
KOZLOUDJA
SIMITLERI
ACIKLI
TCHANAKTCHI
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TCHERKOVO
NOVA ZAGORA
RAGINA
HAMZALARI
NOVA-MAHALA
KAZANKA
KOLENA
ORHAHOVITZA
ALAGUN
DALBOKI
ADATEPE
RICHTENI
EMCHER
BALAKLI
STARA-ZAGORA
MAHMOUDLARI
KOLVACHEVO
BALDJILARI
MISSILIMI
SADAKLI
NOVA-MAHALA
KALFA
RAILWAY TO JAMBOLI
TCHIRPAN
MARITZA RIVER
SOFIA RAILWAY TO ADRIANOPLE AND CONSTANTINOPLE
TIRNOVA-SEYMEN
ROAD TO ADRIANOPLE
HASKOVO
25°27'
26°
VICH

NAME OF CANTON.	QUANTITY OF ROSES USED, IN KILOS.			NO. OF STILLS.	
	1891.	1892.	1893.	1892.	1893.
I.—Kézanlik ..	1,752,000	1,643,000	1,909,500	3,053	3,180
II.—Strema ..	1,850,000	1,674,200	1,893,300	2,200	2,360
III.—Sarnagora ..	596,900	561,600	520,400	780	807
IV.—Stara Zagora	144,000	129,700	174 700	290	305
V.—Ovtchehlin ..	145,700	127,500	156,000	200	270
VI.—Nova-Zagora	130,500	112,300	202,800	187	265
VII.—Tchirpan ..	135,200	102,900	152,800	220	255
VIII.—Pechtera ..	220,000	270,000	280,000	360	450
Kilos	4,974,300	4,621,200	5,289,500	7,290	7,892

Rose Cultivation in Germany.

In 1886 a rose plantation was established at Miltitz, about five miles south-west from Leipzig, by Messrs. Schimmel and Co., and, owing to the great success of the experiment, was further extended in 1889. In 1891 it was reported that the extent of land under this cultivation had been increased to eighty-five acres. More recent reports confirm the general opinion that this undertaking is a growing success, a fact not to be marvelled at, considering the patient study of the subject made by this firm, the enormous outlay they have made, and the labours of the talented men in their employ. At first the *Rosa centifolia* was grown, but in 1888 the firm procured a considerable number of plants of *R. damascena*, Miller, from Bulgaria, which increased rapidly under suitable treatment, and it was found that these roses from Kézanlik flourished excellently in the porous, chalky, loamy soil of the Saxon plains; a widely ramified system of irrigation and drainage having been constructed in order to ensure a supply of water to the deep striking roots of the plants. It appears that as here grown the yield of flowers is equal in weight to that obtained in Bulgaria.

From 115 to 160 of such well developed flowers, just as gathered, go to the pound, but it requires as many as 275 faded ones to make up that weight.* The green parts of the flower, *viz.*, the sepals and receptacle, constitute about seventeen per cent. by weight of a fully developed freshly gathered rose unmoistened by rain.

The factory is situate close to the Klein-Miltitz station of the Thuringian Railway at the southern end of a rose field extending without interruption over a surface of about fifty acres. This factory is constructed on the most rational principles and equipped with the best modern appliances. Every forenoon during the harvest, the freshly gathered flowers reach the factory within a quarter of an hour at most of the time of being gathered, and in traversing this short distance are not tightly packed, but distributed in baskets of moderate size. The hall in which they are placed when they reach the factory faces north, and is exceedingly cool, while in the factory itself care has been taken to secure the lowest possible temperature.

There are four stills which can easily accommodate a charge of *thirty hundredweights of roses in each,* and the combined plant is able to extract without difficulty the otto from *fifty tons of roses in the space of twelve hours.* The stills are charged and emptied automatically in the course of a few minutes, and a few hands are sufficient to deal with the output of a whole working day. The stills are heated by steam. The total heating surface of the boilers covers about 360 square yards. The method of distributing the heat, the amount of heat applied, and the duration of its action on the flowers have all been considered in the construction of these stills, in order to suit them as far as possible to the delicate nature of the otto; nevertheless the oil does not pass through these stills without being to some extent chemically affected in a way slightly detrimental to its *true* odour. It is probably to the Southern French that we are indebted for the invention of treating the roses by a process which extracts the odour in an unimpaired condition. This process, known as "maceration," consists in stripping the flowers of their green parts and steeping the petals and anthers in purified grease, then extracting this grease (or pommade) with pure alcohol, so obtaining what is known as the "Extrait." Although extreme cleanliness is observed throughout the rooms used for the preparation of the oil of rose, it is nowhere carried to greater perfection than in the rooms devoted to the manufacture of the "rose pommade." In these the floor and walls are covered with China tiles, which contrast beautifully with the glittering copper of the machinery. The whole premises are lighted by electricity. The otto of rose introduced into commerce by this firm will remain liquid at ordinary temperatures, will readily dissolve in spirit, and, used in the preparation of compound bouquet perfumes, will not deposit stereoptene, by reason that the bulk of that odourless substance has, in course of manufacture, been abstracted from it. Of course this oil is more powerful than the crude oil *in proportion to the amount of stereoptene abstracted*, but it is also proportionately sensitive to oxidation in consequence of its fluid character causing it to be more exposed to the action of the oxygen of the air than is the case with the crude oil containing stereoptene, which is semi-solid at ordinary temperatures. It therefore appears necessary to store this German oil in small bottles, or of a size according to the consumption. The original bottles in which it is supplied vary in capacity down to fifty grammes; they are of yellow glass, and on the white leather cap covering the stopper, is the seal of the firm.

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* Experience teaches that over-matured roses, showing a more or less clearly defined violet tinge, contain less oil than others. This applies in a much greater degree to the white, or only slightly pink tinged roses.

After a series of experiments, Messrs. Schimmel have succeeded in preparing an extraordinarily strong and perfectly permanent rose water. This is prepared in two strengths, viz.:—

"Double"—distilled from two parts by weight of roses to one part by weight of water.

"Sextuple"—distilled from six parts by weight of roses to one part by weight of water.

Both are obtained directly from the roses for this special purpose, and are *not* a by-product in the distillation of rose oil. The sextuple rose water represents the *highest obtainable concentration.* If placed in ice overnight, small drops of oil, clearly discernable, separate out on the surface. Given normal flowers, a rose water prepared from more than six times its weight of roses would only retain the whole of its oil in solution at a temperature above the normal point, and thus become practically useless. A great advantage of the "Sextuple" rose water is that it enables the buyer to make a considerable economy in freight and duty, as, from one kilo of this water three kilos of rose water of ordinary concentration can be prepared by the simple admixture of two kilos of distilled water (or boiled and well filtered water.)

Rose Cultivation in France.

In the south of France, especially in the neighbourhood of Grasse, the cultivation of the rose has enormously increased, principally for use in the manufacture of rose pommade and the spirituous extract therefrom, the demand for which is very great. Large quantities of flowers are also used in the distillation of rose water, during which process otto of rose is collected as a by-product. The French otto is more green in colour than the Bulgarian, and has a greater consistence, containing more stereoptene; this is explained by the fact that it is the first runnings of the still, and the stereoptene being insoluble in water always comes over with the first part of the distillate, and separates on the surface of the water with the otto. At Grasse 8,000 to 10,000 kilos of rose petals (without the green parts) yield only one kilo of this oil. It is of very superior odour, and, accordingly, high in price, especially considering the large amount of stereoptene it contains.

The variety of rose there grown is the *R. centifolia,* Linn. The bushes are set in rows, but not so close together as to form thick hedges, as in Bulgaria, nor do the plants attain such a height. Ground gently sloping to the south-east is preferred. Young shoots are taken from a five year old tree, and are planted in ground which has been well broken up to a depth of three or four feet. When the young plant begins to branch out, the top of it is cut off about a foot from the ground. During the first year the farmer picks off the buds that appear, in order to develop and strengthen the plant. In the fourth or fifth year the tree is in its full yielding condition. A rose tree will live to a good age, but does not yield much after its seventh year; at that period it is dug up and burned, and the land planted with some other plant for one year.

The flowering begins about mid-April, and lasts through May to early June, a time so short that difficulty is experienced in dealing with the enormous quantity of blossom produced, for of course loss of perfume occurs if the flowers are not immediately used. The buds on the point of opening are picked in the early morning. On some days as many as 150 tons of roses are gathered in the province of the Alpes Maritimes. At the factory the petals are first completely separated from the green parts; this work is done by women, seated at long benches under a shed. The separated petals, of which there are sometimes as much as four tons accumulated on the floor at one time in one factory, are then either distilled with water for the production of rose water, or they are subjected to the process of maceration in warm fat or in olive oil for the purpose of obtaining the perfumed pommade or oil, and these products afterwards finished off by the process of "enfleurage," or "absorption." This consists in spreading the grease thinly on glass trays and spreading rose petals on the surface, changing the flowers daily until the grease is sufficiently impregnated. By this *cold process* the natural delicacy of the perfume is in no way changed. From such pommade the "extrait de rose" is afterwards obtained by agitation with alcohol and then congelation; the fat being frozen the spirit is readily separated.

Physical Properties of the Otto.

Tests of Purity, Chemical Constitution, Etc.

Pure otto of rose is, at the ordinary temperature, a very pale yellow, or pale green, or nearly colourless liquid, according to its source. Its specific gravity at 20° C. varies from 0·855 to 0·865. A reduction of temperature causes it to assume the appearance of a concrete mass, by reason of the formation of crystals of stereoptene in brilliant plates and aigrettes reflecting the prismatic colours. The proportion of crystals forming in the liquid varies according to the geographical position of the country in which the flowers producing it are cultivated, the degree of temperature at the time the flowers are gathered, and other causes more obscure. According to Bauer, it solidifies at between 11° and 16° C. In some experiments made by Hanbury in 1859,* the point of solidification of pure Turkish otto varied between 16° and 18° C., that of an Indian sample was 20° C., one distilled in the south of France was between 21° and 23° C., one distilled in Paris was 29° C., and one obtained in London by distilling rose water was between 30° and 32° C. Those results indicate that the cold climates of the north are unfavourable to the production of a very odoriferous oil, the high points of solidification resulting from a larger proportion of stereoptene, which is an inodorous constituent of no value to the consumer, but valuable to the fraudulent dealer, who takes advantage of its high proportion, and can thereby add a proportionately larger quantity of geranium oil as an adulterant.

The proportion of stereoptene content is certainly very variable. The Turkish oil may contain eighteen per cent., the French thirty-five per cent., and samples produced in colder climates have been found to contain forty-two, sixty, and even sixty-eight per cent. of this inodorous substance. Thus, a rose grown in a cold or temperate climate is not so powerfully fragrant as one grown in a warm or hot climate, even if the amount of otto produced in its petals were the same in quantity, which is not the case, the statistics given on page 40 showing that the yield in Bulgaria is over 0·03 per cent., and the yield recorded at the Leipzig plantations* is only 0·02 per cent.

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* Pharm. Journ. [2] xviii. p. 504.

For many years past chemists have been occupied with researches into the composition of both the solid and fluid constituents of rose oil. As regards the solid, stereoptene (which can be separated by mixing the oil with three times its volume of seventy per cent. alcohol, freezing, and filtering), its nature was studied by Flückiger in 1869,† and by Gladstone in 1872.‡ Flückiger says§ :—"A drop of stereoptene let fall on paper is not dissipated by the heat of a stove, even after several days. When it is carefully melted at the temperature of sun-heat and then allowed to cool, it sets in microscopic crystals of a peculiar form, most of them being truncated hexagonal pyramids, which, nevertheless, do not belong to the rhomboidal system, as their angles are manifestly unequal; many of them are curved into the form of an S or §. Examined under the microscope by polarised light, they present, by reason of their refractive power, a very brilliant aspect. Stereoptene is a very stable, unalterable body, but on boiling it for several days in fuming nitric acid it slowly dissolves and decomposes into various acids, homologues of the fatty acids, and possibly also fumaric acid. Amongst the former, butyric and valerianic acids are recognisable; the principal product, however, is succinic acid, which was found in pure crystals, giving the well known reactions. According to experiments of the same observers, there are many points of resemblance in the physical characteristics of stereoptene and paraffin."

More recent experiments made by Schimmel and Co.|| showed that by digesting stereoptene at a temperature near to its melting point, it was possible to obtain, by crystallising, fractions of different melting points, and by repeatedly putting the substance through these operations, two constituents were finally obtained, one of which melted at 41° C. and the other at 22° C. The result of this experiment on Turkish stereoptene was confirmed by repeating it on stereoptene of known purity resulting from the distillation of roses grown by themselves. It is, therefore, manifest that contrary to the views hitherto held, rose oil stereoptene is not a uniform substance, but a mixture of what are probably a whole series of homologous hydrocarbons.

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* Schimmel's Report, Oct., 1893. † Pharm. Journ. [2] x. p. 147. ‡ Journ. Chem. Soc. x. p. 12. § Hist. Des Drogues, 1878, i. p. 473. || Bericht, Oct., 1890.

In a previous report of the same firm* the following information is given respecting the detection of spermaceti in rose oil: "The stereoptene of rose oil is not altered by boiling with alcoholic potash solution, whilst spermaceti, which is essentially palmitic-cetyl-ether, is saponified by that reagent, with the formation of potassium palmitate and cetyl alcohol. Upon this fact, the following method of examination is based :—

"1°.—*Isolation and determination of the stereoptene.*—Fifty grammes of oil are heated with 500 grammes of 75 per cent. spirit at a temperature of 70° to 80° C. Upon cooling, the stereoptene separates nearly entirely. It is removed from the liquid and treated similarly with 200 grammes more of 75 per cent. spirit, and this operation is repeated until the stereoptene is obtained perfectly odourless; a second treatment of the crude stereoptene being usually sufficient.

2°.—*Determination of an admixture of spermaceti.*—Three to five grammes of the stereoptene are boiled for five or six hours in a vessel with a reflux condenser with twenty to twenty-five grammes of five per cent. alcoholic potash solution; the alcohol is then driven off and the residue treated with hot water. Upon cooling, the greater part of the stereoptene separates on the surface as a crystalline mass. The alkaline liquor is then poured off, the stereoptene washed with some cold water, then again melted down with hot water, allowed to cool, and the water poured off, and this is repeated until the wash water is neutral. The united aqueous liquor is shaken twice with ether, to remove suspended stereoptene, and after separation of the ether is acidulated with dilute sulphuric acid and again extracted with ether, which, upon evaporation should leave no residue (fat acid). As a check, the stereoptene, including that withdrawn from the alkaline liquid, is dried at 90° C. and weighed. There will, however, be a small loss due to the volatilisation of some stereoptene. In a control experiment in which 1·7 per cent. of spermaceti was added to a sample of Turkish oil, 1·5 per cent. was recovered."

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* Bericht, April, 1889.

The method in use in Bulgaria to detect the amount of adulteration with oil of geranium is very simple, and very defective; it is called the congelation test, and is based on the fact that the addition of geranium oil lowers the temperature of congelation of the otto in proportion to the quantity added. Presuming that a perfectly pure Bulgarian otto congeals at from 14° to 16° Réaumur it will, if geranium oil be added to it, only congeal at 13°, 12°, 11°, and even lower according to the amount of "geranium" added. The purchaser takes a twenty-gramme flask containing fifteen grammes of the otto to be tested, and plunges this bottle into a basin of water, the temperature of which is regulated by the addition of hot and cold water, and read off on a Réaumur thermometer. In a pure oil the congelation commences in three minutes, and at the end of ten minutes should be so complete that on turning the flask upside down the contents should not run out. Payment is made according to the degree marked by the thermometer when this congelation is arrived at; the degree of congelation indicating the degree of adulteration.*

Christo Christoff, of Kézanlik, states that "formerly paraffin was added to the otto, in which it dissolves very well, and in spite of the presence of geranium the congelation takes place at 15° R. to 16° R., but the crystals are opaque, of a dirty yellow, and break up, forming a sort of muddy substance which collects at the top of the flask. The simplest method of adulteration consists in adding to the roses to be distilled some white roses, the product from which, though less fragrant, is much richer in stereoptene than that of the red rose; furthermore, this otto, which normally would congeal at 16° R., can, by geranium, be brought down to 14° R., and still remain within the prescribed limits."

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* In the Report of Christo Christoff, of Kézanlik, from which the above information is taken, the temperatures are given in degrees of Réaumur, a scale which appears to be still in use in Bulgaria. To convert degrees of Réaumer to degrees of Centigrade, $R \div 4 \times 5 = C$. To convert Centigrade to Farenheit, $C \div 5 \times 9 + 32 = F$.

Besides the ordinary crystallising test above explained, it would be well to examine the *manner of crystallisation* in order to ascertain if that crystallisation be caused by stereoptene or by spermaceti. The crystals should form in brilliant plates and in aigrettes reflecting the prismatic colours, *in all parts of the liquid.* Spermaceti is precipitated in a solid mass, easily recognisable, besides which its melting-point is 50° C., as is that of most varieties of paraffin; the microscopic crystals of the last, although somewhat resembling those of stereoptene, are easily distinguishable by careful comparative examination.

A test for the presence of the oils of rose geranium, palma rosa, etc., is described by Ganswindt*:—"On mixing a few drops of pure oil of rose with an equal bulk of sulphuric acid, the rose odour is not changed, but oils used for adulteration change their odour; or five drops of the oil are mixed in a dry test tube with twenty drops of pure concentrated sulphuric acid; when the mixture is cool it is agitated with twenty grammes of absolute alcohol, when a nearly clear solution should be obtained, which, heated to boiling and then allowed to cool, remains clear yellowish brown. In the presence of the oils of rose geranium, etc., the alcoholic mixture is turbid, and on standing separates a deposit without becoming clear."

The above mentioned test has been confirmed ten years later by Panajotow,* who mentions that the brownish red fluid resulting from the mixture of equal parts of oil of rose and concentrated sulphuric acid dissolves completely in ninety-five per cent. alcohol to an almost colourless solution, while the similar product resulting from oil of geranium is rendered turbid by the addition of alcohol, and a yellow, fatty, flocculent mass separates.

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* Amer., Journ. Pharm. 1881, p. 250.

O. F. Müller has recently observed that a number of resins, oils, and lacs yield colour reactions with fuchsin solution decolourised by sulphurous acid, the so-called "Schiff's reagent." Applying this test, Panajotow found† that if two or three drops of "Indian geranium oil" be shaken in the cold with two c.c. of the reagent, it gives at first a blue violet, and after two hours a beautiful blue colouration. Under the same conditions *pure* otto of rose only gives a red colouration after twenty-four hours, and hence the slightest admixture of geranium oil is recognisable, because the bluish colouration is always formed at once.

This test is, however, condemned by certain distillers of otto of rose as perfectly inefficient and useless, by reason that the reaction is occasioned by the *presence of an aldehyde*, citral or geranium aldehyde, formed by oxidation of geraniol. This is coloured by the reagent at first blue violet, after some time a turbid greenish blue; whilst the aqueous liquid assumes an intense blue violet colour. As hereafter shown, the bulk of the liquid portion of otto of rose consists of geraniol (the alcohol which Eckart called Rhodinol), and as this readily yields on oxidation citral (geranium aldehyde, or more correctly Geranial), also as this oxidation is partially effected when the otto is exposed to the air, the fuchsin-sulphurous acid test cannot be depended upon.

As regards the *fluid* constituents of otto of rose. The papers that have been published upon this subject generally agree in describing them to consist mainly of an alcoholic body, but they contradict each other with regard to its chemical constitution. Thus: investigations made by Eckart, at the Breslau University* resulted in his arriving at the conclusion that the bulk of the liquid portion of the samples he examined consisted of a body isomeric with, or nearly related to Geraniol, to which, arguing from its chemical characteristics and from analysis, he gave the formula $C_{10}H_{18}O$, and called it *Rhodinol.* (He also found that both the Turkish and German oils submitted to him contained about five per cent. of ethyl alcohol, which he distilled off below 100° C. As both specimens were of undoubted purity, the source of this ethyl alcohol could only be conjectured—either ethyl alcohol is a natural constituent of rose oil, that is to say, occurs already formed in the petals, which in such quantities is very improbable, or it is formed by some kind of secondary process during the distillation or transport of the roses, which is a postulate easier of acceptance; indeed this explanation has since been given as regards the German product by the fact that in 1892, the manipulation of the crop being effected in a more rapid and careful manner, no ethyl alcohol at all was met with. It can therefore be assumed with a certain degree of certitude that the ethyl alcohol was a product of fermentation. The roses packed in baskets one above another, or in sacks, soon undergo a spontaneous fermentation during transport in hot weather. They are also subject to the same change when piled on the floor of a factory. The German 1892 crop had not to undergo any transport, the factory being in the centre of the plantation, and the roses being thrown into the apparatus freshly plucked from the bushes, it is readily understood why no ethyl alcohol could be detected in the product.)

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* Berichte d. Deutsch. Chem. Ges. xxiv. p. 2,700. † *Loc. cit*

Eckart's statements may be abstracted as follows:—"The stereoptene is separated by dissolving the otto in 75 per cent. alcohol at 70°—80° and cooling to 0° C. The alcoholic solution is then evaporated in a vacuum to obtain the Rhodinol. The physical constants of this body vary according to its source, between the following limits:—Boiling point 216—217° C., refractive index 1·4710—1·4725; refraction equivalent 48·97—49·28; dispersion 11·1—12·5; specific rotation —2·7 to —2·8. The vapour density corresponds with the molecular weight

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* Inaugural Dissertation, Breslau, 1891; Archives der Pharm. 1891, pp. 355—389; and Pharm. Journ. [3] xxi. p. 664.

142·43 ($C_{10}H_{18}O=154$). Rhodinol shows all the reactions of an alcohol. Oxidation with potassium bichromate and sulphuric acid converts it into an aldehyde, *Rhodinal*, believed to be an isomer of, and closely resembling, Citral, which can be obtained from Geraniol by similar treatment."

The above statements of Eckart have subsequently been fully corroborated by Barbier,* who obtained bi-hydrochlorate of dipentene by treating rhodinol with dry hydrochloric acid. From this combination he liberated the dipentene, which he recognised by its tetra-bromide melting at 124°. Barbier also obtained the acetic ester of rhodinol. It yielded back unaltered rhodinol upon saponification and possessed the formula $C_{10}H_{17}OC_2H_3O$; whereas, according to Reformatzky and Markovnikoff, its formula is $C_{10}H_{19}OC_2H_3O$. These last named authorities examined three samples sent to them by the Bulgarian Government.†

The following is an abstract of the most important portions of their paper:—"The crude oils turned the polarised ray of light to the left, as follows:— − 3° 34·5′, − 3° 53′ and − 3° 20′. The separation of oil and stereoptene was effected by filtration at 0° and at — 55° C. From the liquid portion a principal fraction having a boiling point of 222° — 225° was next isolated by fractional distillation. The analysis of a fraction boiling at 224·7° gave the formula $C_{10}H_{20}O$. The authors call the principal constituent, which possesses alcoholic properties, *Roseol*. From this roseol they prepared an acetic ester, with a boiling point between 235° and 236°. Saponification of this ester resulted in the recovery of the roseol. The action of dehydrating agents converted the alcohol into a hydrocarbon of which the analysis responded to the formula $C_{10}H_{18}$, rather than to that of $C_{10}H_{16}$. Treated with chromic acid solution, roseol oxidised into an aldehyde of a lemon or melissa-like odour. Its sodium-bisulphite compound was crystalline."

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* Derivés et constitution du Rhodinol de l'essence de roses, Comptes Rendus, cxvii. p. 771. † Ber. Deutsch. chem. ges. 1890, p. 3191; Journ. f. prakt. Chem. [2] xlviii. p. 293; Pharmaceutische Zischr. für Russland xxxii. p. 102; and Journ. Russ. Chem. Soc. xxiv. pp. 663-686.

As, up to the time of these researches, "rhodinol" had not been found in any essential oil other than rose oil, it was generally taken for granted that this body was peculiar to the rose, and that the plebeian geraniol (supposed to bear the same relation to rhodinol as common tin to noble silver) was a characteristic constituent of other plants of a rose-like odour, such as certain species of pelargonium and andropogon. Monnet and Barbier recently opposed this opinion in a treatise bearing the title "Sur une nouvelle source du Rhodinol."* In this paper they maintained the existence of considerable proportions of rhodinol both in French and in African oil of geranium mixed with other substances which disguise its nature. It is evident that this discovery, if proved to be correct, would have been of the greatest possible practical importance; for if rhodinol could be obtained in a pure state from geranium oil the road would have been discovered to the synthetic preparation of rose oil. Unfortunately the alleged discovery has proved to be without foundation.

Shortly after the publication of the treatise in question, experiments in the isolation of rhodinol from oil of geranium were made by Drs. Bertram and Geldemeister in the laboratory of Messrs. Schimmel and Co., but without success. Messrs. Schimmel and Co. state, in their report of April, 1894 :—"We did not succeed in obtaining a body possessing the properties of Eckart's rhodinol, but we were able to satisfy ourselves that the fractions in which rhodinol should have been found consisted in reality, for the greater part, of Geraniol (the smell and other characters of which were modified by the presence of a small proportion of substance leaving an odour of mint)." They mention† that the published data relating to the physical characters of the product obtained from rose oil and named rhodinol and roseol are discrepant, as shown on the next page.

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* Compt. rend. cxvii. p. 1092. † Journ. f. prakt. Chem. [2] xlix. p. 185.

AUTHORITY.	SOURCE.	SPECIFIC GRAVITY.	BOILING POINT	M.m.	ROTATION.
Eckart	German Rose Oil	·8837 at 15° C.	216° C.*	Normal.	— 2°·8
			110° — 120°	12	
	Turkish Rose Oil	·8804 ,, 15°	216° *	Normal.	— 2°·7
		·8789 ,, 18°	217° *	,,	— 2°·7
		·8813 ,, 12°	112° — 120°	12	
Markovnikoff and Reformatzky	Bulgarian Rose Oil	·87846 ,, 20°	224°·7	759	— 3°·20′
Barbier	Turkish Rose Oil	·8956 ,, 0°	126°·5	16	— 2°·37′
Monnet and Barbier	Turkish Rose Oil	·8896 ,, 0°	124°	14	— 2°·37′
	French Geranium Oil	·8886 ,, 0°	124°	14	— 2°·34′

* These boiling points were determined by the Siwoloboff method (Ber. Deutsch. Chem. Ges. 186, p. 795).

Eckart states that rhodinol cannot be distilled unaltered except under reduced pressure. Markovnikoff and Reformatzky state that roseol can be distilled without change under ordinary pressure. Owing to such differences in the statements of various authors, we were compelled, in the course of our investigations, to prepare the alcohol for purposes of control, from rose oil. It then appeared, to our surprise, that by far the greater part of the supposed rhodinol consisted of *Geraniol*, besides which only small proportions of a honey-like smelling body, which has not yet been further inquired into, are present. In conducting this investigation, Bulgarian oil of 1893 was freed from stereoptene by mixing it with three times its volume of 70 per cent. alcohol, freezing and filtering. After distilling off the alcohol a pale yellow oil remained of sp. gr. ·8863 at 15° C. Optical rotation — 2° 56′ for 100 m.m. By saponification with alcoholic potash the amount of acetic ether present was found to be only 6·3 per cent. for an alcohol of the formula $C_{10}H_{18}O$. On distilling the oil at 11 m.m. pressure it began to pass over at 100° C., and when the temperature had risen to 159° there remained a thick liquid having the smell of sesquiterpene.

By distilling under a pressure of 9 m.m. three fractions were obtained, the second and third being the largest :—

1. At 101° — 106°
2. ,, 105° — 115°
3. ,, 115° — 145°

Under normal pressure the oil was separated into four fractions at the following temperatures, the second and third being largest, but no decomposition was observed :—

1. At 215° — 228°
2. ,, 228° — 230°
3. ,, 230° — 233°
4. ,, 233° — 240°

The boiling point of the principal portion of the oil being that of geraniol, the presence of that alcohol was tested for by conversion into the calcium chloride compound described by

Jacobsen*. From this combination geraniol was liberated by treating with water, the product boiling between 106°·8 — 107°·2 under 8 m.m., and under normal pressure between 229° — 230° C. It had a sp. gr. of ·8817 at 15° and presented the other characters of geraniol. The amount of this constituent in Turkish rose oil was estimated at 90·4 per cent. German rose oil (distilled by ourselves, and therefore absolutely pure) examined in a similar manner, proved to have the same composition. The geranyl acetate present amounted to 4·4 per cent. By distillation under 10 m.m. the oil almost all distilled over between 116° — 140°, the first fraction amounting to 88 per cent., passing over between 110° — 111°, and distilling under normal pressure without residue between 228° — 232°. The difference observed in the case of Turkish oil may have been due to its distillation by open fire and partial resinification or change thus effected.

Geraniol being the chief constituent of Palmarosa oil (Indian geranium oil from *Andropogon Schœnanthus*) the geraniol prepared from that oil was examined and found to correspond with the geraniol of rose oil. Similar results were obtained with geraniol prepared from African geranium oil, obtained in Algiers by distilling the leaves of various kinds of pelargonium with water. We have already shown that citronella oil contains geraniol, and it proves to be identical with that from other sources.

During the investigation the identity of Licarhodol (obtained by Barbier by heating Linalöol with acetic anhydride)† with geraniol, was also established.

The following table will be found useful for the purpose of a handy comparison of the chemical and physical properties of geraniols from different sources :—

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* Ann. Chem. clvii. p. 234. † Compt. Rend. cxvi. p. 1,200.

ORIGIN OF THE GERANIOL.	BOILING POINT IN VACUO.	BOILING POINT UNDER ATMOSPHERIC PRESSURE. (756 m.m.)	OPTICAL ROTATION.	SP. GR. at 15 C.	n_D. at 15°.	ACTUAL MOLECULAR REFRACTION.	THEORETICAL MOLECULAR REFRACTION.
1.—Palmarosa Oil (Andropogon Sch.) ..	107°·4—108°·2 at 8 m.m.	229° —230°	Inactive.	0·8834	1·4786	49·28	For $C_{10}H_{18}O$ with 2 Ethylene-molecules 48·78.
2.—Geranium Oil (Pelargonium) ..	109° —109°·5 at 9 m.m.	228°·5—229°·5	,,	0·8801	1·4766	49·31	
3.—Turkish Rose Oil ..	106°·8—107°·2 at 8 m.m.	229° —230°	,,	0·8817	1.4771	49·25	
4.—German Rose Oil ..	107° —107°·6 at 8 m.m.	229° —230°	,,	0·8829	1·4773	49·20	
5.—Citronella Oil *(Andropogon Nardus)	106°·5—107° at 8 m.m.	229° —230°	,,	0·8826	1·4766	49·16	
6.—Linalöol (Licarhodol)	110° —111°·2 at 9 m.m.	229° —230°·5	,,	0·8830	1·4766	49·30	

* The separation of Geraniol from oil of Andropogon nardus is hereafter described.

This table shows that the physical properties of the alcohols obtained from the different raw materials described in it are absolutely identical. The same is the case with regard to their odour, taste, solubility, &c. The slight differences in specific gravity may be due to the ready oxidation of geraniol, and to partial formation of citral and other products by exposure to air.* As to the chemical relations of the alcohol of rose oil and the geraniol from other sources, it appears from the nature of the products obtainable by the action of dehydrating agents that the composition of this body is represented by the formula $C_{10}H_{18}O$. Eckart showed that by treatment with phosphoric anhydride, rhodinol loses one molecule of water, and that dipentene is formed.† Monnet and Barbier confirmed the formation of dipentene, but they obtained this terpene by passing dry hydrochloric gas into rhodinol.‡ Barbier had also obtained dipentene from the geraniol of Palmarosa oil.§ Bertram and Gildemeister have since obtained terpene by the action of formic acid upon geraniol, but terpinene is also formed, and this change points to the formula $C_{10}H_{18}O$. The production of citral from "rhodinol" by oxidation is also important. Eckart obtained,|| by treatment with chromic acid, an aldehyde smelling like lemon, $C_{10}H_{16}O$ which he named rhodinol, and subsequently Tieman and Semmler¶ proved its identity with citral, showing that the formula of rhodinol must be $C_{10}H_{18}O$ instead of $C_{10}H_{20}O$ that adopted by Markovnikoff and Reformatzky, and citral had long before been obtained by Semmler from geraniol.** The acids produced by this oxidation, called by Eckart *rhodinolic acid* and by Semmler *geranic acid*, are also the same body. Potassium permanganate oxidises geraniol to isovalerianic acid,†† and Eckart also obtained valerianic acid among the oxidation products of rhodinol. It may therefore be regarded as proved that the products named "Rhodinol" and "Roseol" were only impure substances consisting essentially of geraniol, and that Barbier's "Licarhodol" was the same thing. The slight deviations in the properties of geraniol are due to the presence of small proportions of foreign substances, the nature of which has yet to be ascertained."

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* Journ. Prakt. Chem. [2] xlviii. pp. 299, 302. † Archiv. pharm. ccxxix p. 372. ‡ Compt. Rend. cxvii. p. 1,094. § Ibid. p. 121. || Archiv. der pharm. ccxxix. p. 372. ¶ Ber. Deutsch. Chem. Ges. xxvi. 2,714. ** Ibid. xxiv. p. 203. †† Ber. Deutsch. Chem. Ges. xxiii. 1,102.

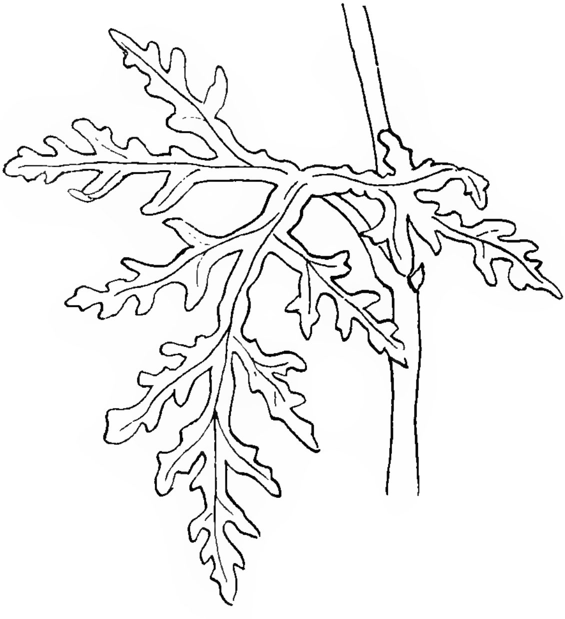
In all probability Messrs. Schimmel's discovery will not remain long without practical results. In future the purity test of rose oil will have to be based upon other assumptions than those from which investigators have hitherto started. Some of the tests now in use will, of course, retain their value. Among these are the aroma test, the determination of the physical character, melting point, freezing point, and optical rotation, the determination of the percentage of stereoptene and the test of the latter for spermaceti, stearin, etc. On the other hand, the determination of the geraniol (rhodinol) per centage would appear superfluous, as the oils used as adulterants of rose oil also contain large proportions of geraniol.

In order to find a scientific basis for the chemical examination of rose oil it is necessary, above everything else, to investigate the character of the odoriferous bodies which are present in it *in addition to geraniol*, and to find out what is the proportion of these in known pure rose oil. Next to this a renewed and thorough research into the oils used as adulterants, especially oils of palmarosa and geranium is necessary, in order that, in these oils also, the constituents present in addition to geraniol may be determined. The rose oil should then be tested for the presence of such bodies. There is no doubt that the way here indicated presents great difficulties, but yet, if it should be found possible, sooner or later, to determine the body or bodies which are present in rose oil in addition to geraniol, and to prepare them synthetically (a contingency which does not seem impossible of realisation) the extension of rose cultivation for distilling purposes would, of course, come to an end. Nevertheless, the existing plantations would be continued, inasmuch as experience has shown that natural and artificial products may continue to exist side by side in certain proportions.

Perfumes somewhat Resembling the Rose.

Geranium.

The geranium oils known as African, Spanish, French, Réunion, Italian, and Corsican are distilled from varieties of certain species of Pelargonium whose leaves and green parts are rose-scented. These are : *P. roseum,* Willdenow ; *P. capitatum,* Aiton ; and *P. odoratissimum,* Willdenow ; but they may vary slightly from drawings of the primitive plants.



P. radula, AITON.

The *Pelargonium roseum,* Willdenow,* is a hybrid between *P. radula,* Aiton, and *P. graveolens,* Aiton, both of which are rose-scented. The annexed illustration, representing a leaf of *P.*

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* Spec. iii. 679.

radula, Aiton, is copied from a very early volume of Curtis' Botanical Magazine.* Botanists have described it as identical with *Geranium radula,* Cavanilles,† *Geranium revolutum,* Jacquin,‡ and *P. graveolens,* Aiton.§ It is very near to *G. terebinthinaceum,* Cavanilles,‖ (of which there is a variegated sort¶ called by Andrews *G. capitatum, var.* in his work "Coloured Engravings of Geraniums").

Respecting the *P. radula,* Aiton, the writer in the Botanical Magazine observes:—"This is one of the numerous tribe of geraniums introduced from the Cape since the time of Miller. It takes the name of *radula,* which is the term for a rasp or file, from the rough rasp-like surface of its leaves. There are two varieties of it, a *major* and a *minor*, which keep pretty constantly to their characters, but as this species is readily raised from seeds, it affords many seminal varieties."

There exists a great difference in the *perfume* of various pelargonium leaves, although the leaves may be very nearly similar to each other in appearance. Some of the finest scented varieties of *P. radula* seem to be *minor* varieties. Some of the large leaved kinds are rank, and as if the odour were blended with a coarse sort of peppermint, an odour extremely difficult to describe.

In *P. capitatum,* Aiton,** which is identical with *Geranium capitatum,* Linnæus,†† and Cavanilles,‡‡ the rose-scented leaves are cordate, lobed, waved, villous, toothed. *P. vitifolium,* Aiton,§§ is perhaps a simple variety of this species. *P. capitatum,* Aiton, is often cultivated by florists under the erroneous names "*Geranium rosa*" and "*Pelargonium roseum.*" The true *P. roseum,* Aiton,‖‖ identical with the *Geranium roseum,* Andrews,¶¶ introduced in 1792, is now rare in Engand.

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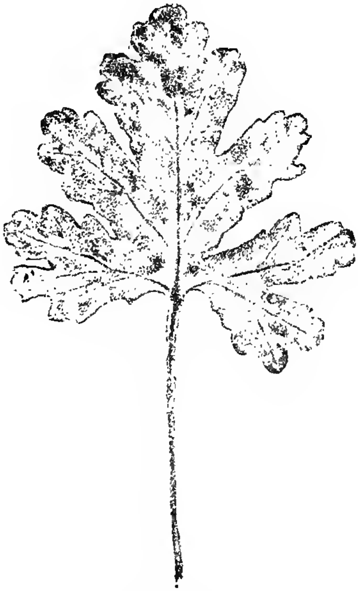
* Bot. Mag. iii. t. 95. † Cav. Diss. iv. p. 262, t. 101, f.i. ‡ Icones plantarum, t. 133. § Hortus Kewensis ii. p. 423, and L'Heritier, Geraniologia, t. 16. ‖ Cav. Diss. iv. p. 250, t. 114, f.i. ¶ Sweet, Hort. Brit. p. 82. ** Hort. Kew. ii. p. 425. †† Lin. spec. 947. ‡‡ Cav. Diss. iv. t. 105, f.i., also De Candolle, Prodromus, i. p. 674. §§ Hort. Kew. ii. p. 425. ‖‖ Hort. Kew. Ed. ii. iv. p. 161; D. C. Prodr. i. p. 651, n. 31; Sweet, Geraneaceæ, t. 262. ¶¶ Bot. Rep. t. 173.

P. odoratissimum, Aiton,* Syn. *Geranium odoratissimum*, Cavanilles,† is also uncommon in this country.

The variety of Pelargonium actually cultivated at Grasse is represented by the annexed illustration, which is a facsimile of a living leaf of a specimen of the plant kindly supplied to me by Messrs. Warrick frères, of Grasse. The plant is propagated by cuttings which are set in well sheltered beds in October. During the frosts they are covered over with straw matting. In April they are taken up and planted in rows in fields or upon easily irrigated terraces. They soon form bushes three or four feet high. At Nice they generally flower at the end of August. At Grasse and cooler places they flower about the end of October. Every part of the plant, just as cut down, is put into the still.



Rubbing from a Living Leaf, re-produced photographically.

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* Hort. Kew. Ed. i. ii. p. 419; Sweet, Geraneaceæ, t. 299. † Cav. Diss. iv. t. 103, f.i.

There are large plantations of Pelargonium in many parts of Algeria, notably at La Trappe de Staoüeli near the Bay of Sidi Ferruch, at Castiglione, at Sahel in the good red soil consisting of a decomposition of micaceous schists, at Boufarik, at Blidah, at Grand Chérakas and at Guyoville, in the environs of Constantine, and in the plains of Métidja close to Algiers.*

Originally the plants were cultivated on dry arid slopes, where they were stunted in growth but yielded a perfume of great delicacy; now, on the contrary, the plantations are established on low-lying and rather humid soil, which yields three crops annually instead of one. By a system of irrigation which floods the plantations, the proprietors force the growth of the plant to a height of about thirty inches, and nearly an inch in thickness in the stem. Under these conditions the oil is produced in much greater abundance, but the quality is sensibly inferior. (This observation on the immediate effect of a moist soil on the secretions of a plant which naturally prefers a dry soil is in accordance with the observations of Linnæus.) The irrigation process is now so general that for one hectare of land cultivated "dry," 200 hectares will be found "irrigated." The very superior product of the "dry" method is rarely sold separately, but is generally mixed with common oil (called "géranium irrigué") to ameliorate the quality.

Ordinary stills are used for the distillation, which is carried on during the whole time of each harvest. It is estimated that 300 kilos of the plant yield one kilo of oil. The plant is gathered a little before the opening of its flowers, when the lemon-like odour which it at first possesses gives place to the odour of rose. The critical point is recognisable by the leaves beginning to turn yellow.

It is highly necessary that the distillation be made at once, while the leaves are perfectly fresh, in order to avoid products of fermentation and oxidation.

It has been absolutely proved (by microscopic examination of a transverse section treated with a solution of osmic acid), that the petals of the Pelargonium do not contain any essential oil whatever, neither do they contain any fixed oil or fatty matter, or even any tannin (verified by the ferric perchloride test). Any odour which may be thought to be perceived in the flower is

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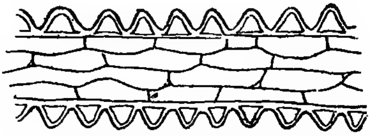
* Exp. de Paris, 1878, Cat. Spéc. de l'Algérie.



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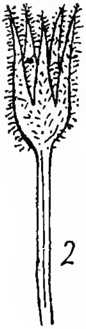

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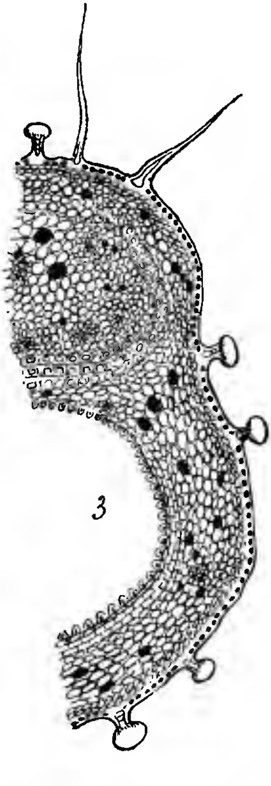

Fig. 1.—*P. odoratissimum.* Transverse section of a petal after treatment with osmic acid, showing entire absence of essential oil.

Fig 2.—*P. capitatum.* Pedicel and calyx.

Fig. 3.—Transverse section of the same (× about 100) showing the pedicellate glands. (After Blondel).

simply due to fracture of the secreting organs in the calyx and stalk caused by the friction in handling these parts. However, in order to avoid waste of time in detaching the flowers, they are put into the still with the branches.

The essential oil is secreted in pedicellated, club-shaped glands on the surfaces of calyces, leaves, leaf stalks, flower stalks, and branches, in fact on every green part of the plant. These glands consist of a pedicel constructed of four cells placed end on end, surmounted by a spherical, one-celled reservoir. An examination of a transverse section of the floral pedicel treated with osmic acid reveals the presence of essential oil in numerous cells of the epiderm and even in some parts of the parenchyma which surround and protect the central cylinder. The leaves, submitted to the action of the same reagent, do not exhibit the presence of essential oil in the perenchymatous mesophyll, but solely in the knobs of the glands, and to a slight extent in some formations of the epidermis.

The Pelargonium is also cultivated and distilled in Spain (near Valencia, and recently in the province of Almeria), Italy, Corsica, Réunion, and in Provence. The Spanish oil is considered the finest (owing either to the fact that the plantations are not "irrigated" or that the plants are more carefully gathered and distilled). It is said to be the produce of the same variety of Pelargonium as the Algerian plant. The oil from Provence ranks equally as regards quality with the Spanish; a "superfine" oil is also manufactured in Provence by adding rose petals to the still. The Corsican oil is only exported in small quantities, but the Réunion production annually increases in importance.

The Réunion oil is of a greenish colour, probably due to the presence of chlorophyllan. In odour it is very fine, and it is much to be regretted that by reason of cyclones the plantations on this island cannot be maintained with any certainty. In 1892 the greater part of the plantations were destroyed by a cyclone, and the recurrence of these disasters does not encourage the planters to start afresh.

In Algiers the plantations are sometimes decimated by locusts, and in Spain they are apt to be ruined by prolonged drought.

Of all the constituents of the various rose-scented Pelargonium and so-called "Geranium" oils, *geraniol* is almost the only one understood. In order to obtain a clearer insight into the chemical composition of these important oils, Messrs. Schimmel and Co. undertook an investigation of them; the results are briefly subjoined:—In all geranium oils investigated up to the present,* geraniol esters have been found, the tiglic acid geranyl ester usually predominating. In addition to tiglic acid, butyric and valerianic acids are possibly present.

A series of quantitative ester determinations of different oils showed that the percentage varies in the different kinds. Réunion oil is the richest in esters, containing about 31 per cent. In all probability the quantitative ester determination will be found useful in ascertaining the value of an oil, in addition to the determination of its physical properties.

It has already been ascertained that it is possible to convert geraniol quantitatively into geranyl-acetate by boiling with acetic-anhydride. The fact was ascertained by the aid of chemically pure geraniol recovered from its calcium chloride combination. (*The process being the same as for the linalöol determination in lavender oil.*†) The geraniol percentage of the oil is calculated from the saponification number of the acetylised product. The higher that number, the larger the geraniol percentage in the sample under examination. The test is of value (in connection with the combination of the physical properties) in estimating the quality of the oils.

* Bericht, April, 1894. † See Odcrographia, ii. p. 426.

The following table gives the physical data, the ester-content, and the geraniol-content of different oils:—

DESCRIPTION OF THE SAMPLES.	SP. GR. at 15° C.	SOLUBILITY IN 3 VOLS. OF 70 PER CENT. ALCOHOL.	OPT. ROTATION IN 100 M.M. TUBE.	ESTER CONTENT CALCULATED ON TIGLIC-ACID GERANYL-ESTER, PER CENT.	SAPONIFICATION NUMBER OF THE ACETYLISED OIL.	GERANIOL CONTENT OF THE OIL, PER CENT.
Geraniol, chemically pure ..	0 8835	Soluble.	Nil.	—	287·2	100·4
Palmarosa Oil	0·894	,,	– 1° 55′	15·0	259	90·5
Réunion Oil	0·890	,,	– 9° 15′	31·3	241	84·3
,, ,, ...	0·891	,,	—9°	31·1	242	84·6
,, ,, ...	0·893	,,	—8° 32′	31·3	243	84·9
,, ,, ...	0·891	,,	—8° 8′	32·5	229	80
,, ,, ...	0·891	,,	– 8° 57′	34·1	227	79·3
African ,, ...	0·898	,,	8° 45′	29·1	235	82·1
Spanish ,, ...	9·898	,,	—8° 12′	23·7	235·5	85·5
Schimmel's Distillate from plants grown at Leipzig ..	0·906	,,	– 16°	27·9	212	74·1

The examination of the following mixtures (prepared for the purposes of test) shows the extent to which these properties vary in adulterated oils:—

Réunion Oil, with 20 per cent. of oil of turpentine ..	0·885	Insoluble.	—13° 28′	25·7	194	67.9
Ditto, with 30 per cent. of fatty oil	0·894	,,	– 5° 48′	48·2	234	81·8

The most noticeable circumstance is that the addition of oil of turpentine not only affects the solubility, but all other properties are also clearly affected. In the presence of fixed oils, which themselves yield a high saponification number, the geraniol and ester percentages are no guide. In this case also the specific gravity and optical rotation undergo but little change. On the other hand a mixture of this kind is distinguishable from normal oils by its insolubility in 70 per cent. alcohol, as well as by the fact that it only partly volatilises under steam distillation.

The geraniol estimation above referred to is based upon the supposition that the alcoholic element of geranium oil consists only of geraniol. Further investigations must show whether this be really so, or whether still other alcohols of the $C_{10}H_{18}O$ or $C_{10}H_{20}O$ formula are present. In short, although the key to the estimation of geranium oil undoubtedly lies in the determination of the geraniol percentage, such determination cannot lead to certain results until the other constituents of the geranium oils are positively known, and research into the still unknown bodies present in these oils is absolutely necessary. It is also certain that the other bodies present in the various oils exercise a very important influence in modifying the character of the aroma possessed by each particular variety. In the case of Palmarosa oil this influence of the subsidiary constituents is without doubt unfavourable, for the odour of the oil is by no means so fine as that of geraniol, and further, even the better varieties of geranium oil cannot compare with pure geraniol.

Indian Geranium.

This oil is distilled in India from the leaves of *Andropogon Schœnanthus*, Linnæus; synonymous with *A. Martini*, Roxburgh, *A. nardoides*, Nees, *A. Pachnodes*, Trinnius*, *A. Calamus*

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* Spec. Gram. iii. t. 327.

aromaticus, Royle*, *A. Iwarancusa*, Schultes,† and *Cymbopogon Martini*, Munro; but *not* the *A. Schœnanthus*, of Wallich,‡ which is identical with *A. citratus*, De Cand., and yields lemon-grass oil. In Modeen Sheriff's "Supplement to the Pharmacopœia of India," the vernacular names of lemon-grass are given under *A. Schœnanthus* instead of under *A. citratus.*

The various vernacular names for the plant in India are:—*Agyaghás* and *Ganda-bena*, Bengal; *Bujina* and *Pala-Khari*, N.W. Provinces; *Mirchia-gard*. Siwaliks; *Rose-gavat* and *Rohisha*, Bombay; *Raúns*, Punjáb.

The oil is known in commerce under a variety of names, such as, in England, "Ginger-grass," "Turkish Oil of Geranium," "Rusa-grass Oil," "Oil of Nimar" or "Nemaur." In the otto-producing districts of the Balkan it is known to Europeans as "Essence of Geranium" and oil of "Palma-Rosa"; in India it is called "Rusa Oil," "Roshel," "Rùsa-ka-tel"; in Egypt, Arabia, and Constantinople it appears under the names of "Idris-Yaghi" and "Entreshah," names which may mislead to the belief in a variety of oils produced from several plants. These names seem to be mostly of modern origin. The name "Rusa-grass" is certainly more appropriate than "Ginger-grass." There is a grass found about old wells near Bombay which really has an odour of ginger, but it is rather a rare plant. The name "geranium oil" has caused much confusion with the true geranium oil derived from various species of *Pelargonium*, and has apparently come into existence from the fact that the so-called "ginger-grass oil" is used to adulterate the true geranium oil, which, in its turn, is used to adulterate the otto of rose. The grass is found growing wild in large tracts in the Northern and Eastern provinces, and particularly in the North-west Provinces and the Punjáb; it is abundant everywhere in the Deccan, in Central India, and is cultivated in Kashmir in localities formerly devoted to the rose. It has recently been discovered in British Beluchistan, by J. H. Lace, Deputy Commissioner of Forests in India. In his valuable paper on the "Vegetation of the Hurnai Railway Route," recently read before the Linnean Society,* he mentions having found it on the lower hills.

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* Illust. Bot. Himalayan Mountains, i. p. 425, t. 97. † Phil. Trans. lxxx. p. 284, t. 16. ‡ Plant. As. Rar. iii. t. 280.

Apparently the first mention made of this oil was by Maxwell in 1825,† but it is only within comparatively recent times that it has had any commercial value. From the fact of one of the largest supplies of Rusa oil being from the Nimar district of Khandésh, Bombay Presidency, the oil has come to bear the commercial name of Nimar, Nimaur, and Namar.

At maturity it is said to be as thick as a lead pencil and from four to five feet high. It is cut during its flowering period and distilled upon the spot.

In the "Pharmacographia Indica," 1893, Dr. Dymock gives the following interesting information concerning this plant and its essential oil: "The grass grows freely, though not very widely, on open hill-sides in West Khandésh, especially in Akráni. The original seat of manufacture was Pimpalner, but as the oil is in great demand, the manufacture has of late spread to Nandurbár, Sháháda and Taloda. The makers are Mussulmen, who, at the close of the rains, about September, when the grass is ripening, buy it from the Bhils, stack it and set stills at the sides of brooks where wood and water are plentiful. They call the grass "*Motiya*" when the inflorescence is young and of a bluish-white colour; after it has ripened and become red, it is called "*Sonfiya.*" The oil obtained from it in the first condition has a more delicate odour than that obtained from the ripened grass. The motiya oil is usually mixed with the second kind, which, by itself, would not fetch a good price in the European market. (This may to a great extent account for the considerable difference in the quality of the two commercial "grass oils," the so-called "geranium oil" and "ginger-grass oil.") Dr. Dymock, describing the manufacture in this district, states that an iron still is used, and only a very small quantity of water added to the grass; when the still is carelessly worked the grass burns, and communicates a dark colour to the oil, which should be of a pale sherry colour when good. The odour at first recalls that of the rose, but this sensation is almost immediately followed by a strong odour of lemon or citron. By rectification the oil is rendered colourless, and the odour of lemon is then much less marked.

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* Journ. Linn. Soc. xxviii. p. 293. † Calcutta Med. and Phys. Trans. i. p. 367.

The oil is packed in skins, and sent on bullock-back over the Kundaibári Pass to Surat, and by Dhulia and Manmad to Bombay.

Dr. Dymock states that 373 lbs. of grass received from Khandésh and distilled under his own superintendence in Bombay, yielded 1 lb. 5½ ozs. of oil.

The oil is largely adulterated in the districts where it is distilled, the distillers being regularly supplied with turpentine from Bombay; the oils of gurjon, coco-nut, ground-nut, rape, linseed, and cotton-seed being also used. With turpentine and ground-nut the resulting turbidity passes off in a day or two, hence they are preferred, especially turpentine, as it is not at once detected by the evaporation test. The oil is exported from Bombay to the Red Sea ports (chiefly Yedda), to Constantinople, Trieste, and London. Before being sent to Turkey, which absorbs the great bulk of it, large quantities are sent to Paris for rectification. In Turkey it is subjected to a special treatment which is said to render it more fit to mix with otto of rose without betraying its odour; this process consists in shaking it with water acidulated with lemon-juice, and then exposing it to the sun and air. By this process it loses its penetrating after-smell, and acquires a pale straw colour. This process was described by Mr. Baur, of Constantinople.*

As found on the London market, Indian geranium oil varies greatly in quality. A distinction is often made commercially between Oil of Palma Rosa and Oil of Indian Geranium, although both are products of the same plant. The superiority of the first is probably due to the age of the plant at the time of its distillation, as above observed.

* Neues Jahrbuch für pharm. Jan. 1867.

(It has been remarked that if geranium oil be kept in tins it acquires a very repulsive odour by prolonged contact with the metallic surface. It is, therefore, advisable to pour the oil into glass bottles as soon as received, and should the smell not disappear, the oil must be poured out and exposed to the air for several hours in an open basin.)

For some years past an "essence of geranium" has been received from Java, posessing all the characters of Palma Rosa, but its exact botanical origin and method of production are unknown. Some samples of Palma Rosa have a decided odour of Lily of the Valley. An oil termed "Huille essentielle de Pataque Malgache" has been introduced from the Island of Réunion, described as distilled from "*Andropogon fragrans*" (evidently a fancy name), with an odour identical with Indian ginger-grass oil.

The sp. gr. of "Indian Geranium oil," according to Semmler,* is 0·8868 to 0·8871 at 16° C. (two specimens being examined), and the optical rotation 20′ to the left, in a column of 100 m.m. (Dr. Dymock found the oil to be dextrogyre, deviating the ray 39° to the right in a 100 m.m. tube, and 78° in a 200 m.m. tube; he appends the remark that some samples of "commercial" oil rotate the ray about 13° to the right, and some have little or no effect upon it. As he further remarks that all "commercial" oil is more or less adulterated, it is inferred that the optical rotation is more or less active proportionately.)

This oil, when pure, forms a clear solution in dilute alcohol in very nearly the same proportions as does oil of pelargonium, so that when fixed oils are present they can be easily detected. A process for the quantitative estimation of fixed oil by saponification with caustic potash has been recommended.†

Pure oil of "Indian Geranium" contains ninety-two per cent. of geraniol. Its other constituents have not yet been investigated. The physical properties of geraniol have been described at page 72.

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* Ber. Deutsch. chem. Ges. xxiii. p. 1098. † *Chem. News*, xxx. p. 293.

By oxidation with potassium permanganate geraniol yields valerianic acid, and by oxidation with chromic acid mixture it is converted into geranium aldehyde, $C_{10}H_{16}O$, which is identical with citral. By further oxidation with argentic oxide, Semmler prepared geranic acid, $C_{10}H_{16}O_2$, a limpid oil, and by treating citral with acid sulphate of potassium Cymol was formed, a molecule of water being abstracted.*

It has recently been ascertained by Dr. Julius Bertram, of Leipzig, that geraniol can be separated from the essential oil of citronella (*Andropogon nardus*), and in such a large proportion that, considering the low price of this oil and its abundant production,† it is evidently the most economic source of geraniol. The process of extraction is protected by patents in various countries and is undoubtedly of great value commercially, but Dr. Bertram appears to have been very nearly forestalled by an American chemist, Mr. F. D. Dodge, whose investigations on the "grass oils" were made at the Organic Laboratory, School of Mines, New York, in 1889,‡ and to some extent by Prof. Kremers at Cincinnati in 1887.§ The following is an abstract from Dodge's paper, describing citronellon or "citronellic aldehyde" (or more correctly *citronellal*), $C_{10}H_{18}O$, also the corresponding alcohol $C_{10}H_{20}O$, which he terms "citronellyl alcohol" obtained by reduction of the aldehyde, also from the remnant of oil after separating out the aldehyde:—"Oil of *Andropogon nardus* is agitated with a saturated solution of sodium bisulphite; after ten minutes the liquid solidifies into a snow-white magma with considerable evolution of heat, the vessel should therefore be kept cool with ice while the two liquids are being well stirred together. If the mass be allowed to stand long it becomes yellow on the surface, owing to oxidation of other constituents of the oil. It is readily purified by being wrapped in flannel, and after draining on a large funnel, carefully pressed in a filter-press, and when nearly dry removed from the press, thinned out thoroughly with ether or chloroform, filtered, and washed with either of the same solvents (in which it is practically insoluble), and again drained and pressed. To remove the residual ether it is exposed to the air for several hours. At this stage it has the appearance of wax or soap. The aldehyde can be readily liberated from this bisulphite by acids, alkalies, sodium carbonate, or hot water. In the experiment described the dry mass was decomposed with crystallised sodic carbonate, in the proportion of 450 grammes of the former to 350 grammes of the latter, in a large flask. Steam was then passed into the mixture, which soon liquefied, and the aldehyde distilled over."

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* Ber. Deutsch. chem. Ges. xxiii. (1890) 3556, and xxiv. (1891) 203

† The average annual export of oil of citronella from Colombo and Galle during the five years, 1889-93, amounted to 337 tons. ‡ Amer. Chem. Journ. Oct., 1889, xi. p. 461. § Proc. Amer. Pharm. Assoc. 1887.

Dodge then proceeds to describe the *reduction of the aldehyde* and production of its corresponding alcohol. He says:—"Twenty-five grammes aldehyde were mixed with thirteen grammes glacial acetic acid. 400 grammes of five per cent. sodium amalgam were gradually added, with occasional washing to remove the acetate formed. The resulting liquid was dissolved in ether, shaken up with bisulphite solution to remove any unchanged aldehyde, boiled with a little alkali to saponify any acetic ester possibly formed, washed, dried and distilled. The greater part boiled at 225° — 230° C. It decolourised bromine solution and possessed a pleasant *odour of roses.* The result of its ultimate analysis agreed closely with the formula $C_{10}H_{20}O$." The same observer also states that after removal of the aldehyde from the crude oil of citronella he carefully fractionated the filtrate from the bisulphite precipitate. He found that it commenced to boil at 185° C. and the temperature rose steadily to 240° C. The quantity examined was 350 c.c. "At the tenth distillation the oil was almost completely separated into three portions. The first, a limpid, colourless oil having a lemon-like odour, boiled at 177° — 180° and amounted to 75 c.c. The second, a somewhat thicker oil, of slightly greenish colour and having a pleasant *rose-like odour,* boiled at 220° — 224° and amounted to 120 c.c. The third portion consisted of products boiling above 240° and was a dark brown viscid liquid, having a pungent odour." An examination was then made of the constituent boiling at 222°, which in the crude state was a somewhat syrupy liquid, *resembling in odour the alcohol obtained by reduction of the aldehyde.* This was purified and analysed. Its composition and physical properties led him to conclude that it was "citronellyl alcohol" $C_{10}H_{20}O$ (or the same body as obtained by reduction of the aldehyde).

Kremers found that "the sodium bisulphite compound could be decomposed by dilute sulphuric acid at a gentle heat, and the sulphur dioxide removed by dry potassium carbonate; the aldehyde thus obtained being a viscid yellow liquid, possessing a *geranium-like* odour."

The following is an abstract of Dr. Julius Bertram's Specification of Patent*:—"My recent investigations of citronella oil have shown that it contains several terpenes, pinene, camphene, and dipentene, as well as the aldehyde citronellon or citronellaldehyde. The alcoholic constituents include a substance which boils between 230° and 235° C., and occurs in very considerable quantities; it was found to be identical with geraniol, the aromatic constituent of palmarosa oil and of geranium oil. This is accompanied by small quantities of fatty acid esters of geraniol and sesquiterpene.

"The recovery of the geraniol in a pure state by means of fractional distillation even *in vacuo* is not immediately practicable because neither the citronellon nor the esters can be removed in this manner. The following methods may, however, be employed for obtaining the geraniol from the citronella-oil:—

1°. The oil is shaken with a sufficient quantity of a solution of sodium-bisulphite, or of potassium-bisulphite. The crystalline bisulphite compound of citronellon thus formed is subsequently separated from the oil mixture by pressure, and the latter heated with an alcoholic solution of potash. After that, the geraniol may be separated from its admixtures by fractional distillation with steam or *in vacuo.*

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* No. 13401, 10th July, 1893.

2°. If no value is attributed to the recovery of the citronellon, the citronella-oil may be directly saponified with alcoholic potash, thereby transforming most of the citronellon into polymeric products, which have a high boiling point, and may be separated from the geraniol by fractional distillation.

3°. The geraniol obtained as described above may also be purified by preparing the crystalline compounds which are formed by combination of geraniol with certain salts, such as the chloride or nitrate of calcium or of magnesium and decomposing these compounds with water. The same process may also be performed on the fractions of citronella-oil which boil from 220° — 235°, without previous purification of the oil with bisulphite of sodium and alcoholic potash.

Examples.—1°. 100 kilos of citronella-oil are shaken with twenty to forty kilos of concentrated sodium-bisulphite solution. After cooling, the oil is removed from the separated bisulphite compound by pressure or suction, and heated with a solution of six kilos of potassium hydrate in twenty-five kilos of alcohol, to the boiling point. Subsequently the alcohol is distilled off, and the oil driven into a receiver by admitting steam. Finally the geraniol is purified by fractional distillation *in vacuo* or with steam.

2°. 100 kilos of citronella-oil are boiled with a solution of ten to fifteen kilos of potassium hydrate in fifty to seventy kilos of alcohol for about three hours; the alcohol is distilled off and the residue treated as indicated in the first example.

3°. Equal parts of powdered calcium chloride and of crude geraniol from citronella-oil are mixed; there results a solid mass which is separated from the oily admixtures by means of pressure, suction, or centrifugal action, and then purified by washing with ether, petroleum-ether, chloroform, or other chemically inert liquids. The remaining solid mass, a mixture of calcium chloride and of a compound of geraniol with that salt, is treated with water, and the regenerated geraniol is separated from the adhering traces of ether, etc., by fractional distillation with steam or *in vacuo*. If a closed retort be used, it is sufficient to heat to 120° C. for an hour.

Instead of alcoholic potash, potassium alcoholate or sodium alcoholate or a concentrated aqueous solution of potash $2\,KOH + 1\,H_2O$ may be employed."

Barbier and Bouveault still assert that Bertram and Gildmeister are wrong in concluding that the alcohols of *Andropogon schœnanthus*, of pelargonium, and of rose are identical. Their researches are recorded in the Comptes Rendus of the Academy of Sciences cxix., 281 and 337; nevertheless, the figures of Dr. Bertram (here-before quoted), appear very convincing.

As above stated (p. 67), geraniol is readily oxidised by chromic acid to the aldehyde geraniol (identical with citral obtainable from the oils of lemon, lemon-grass, and some of the ecalypti). It has been recorded by Tiemann and Semmler* that geraniol can be produced from citral by reduction with sodium, and on the 18th September, 1893, a patent was applied for in England by Dr. Tiemann for "converting compounds of the citral series into isomers," this patent (No. 17540), has been abandoned, but on the 18th November, 1893, another patent was applied for by the same scientist (No. 22114), for "converting compounds of the citral series (geranium series) into isomers." This specification is not yet open to inspection, and is not yet reported "accepted," but the patent is probably based on a method of reducing the aldehyde by sodium.

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* Ber. Deutsch. chem. Ges. xxvi. 2708.

SEVERAL other plants possess, either in their leaves, wood, roots or flowers, a fragrance which is likened to that of the rose, but the likeness is very distant. Amongst such plants may be instanced *Rhodorrhiza scoparia* of the Canary Islands, which yields "Oil of Rhodium;" *Rhus aromatica*, the "Fragrant Sumach" of North America; *Rhodiola rosea*, or "Rose-root," a species of *Sedum* growing on damp rocks on the high mountains of Scotland, Ireland, and the North of England (also on sea cliffs); *Physocalymma floribundum*, the "Tulip-wood of Brazil;" *Dysoxylon Fraserianum* of New South Wales; *Colliguaja odorifera* of Chili*; *Asarum Canadense* of Canada; *Pœonia fragrans* of the North of China†; and *Chamœdorea fragrans* of Bolivia.

THERE are several definite chemical compounds known in the laboratory, which possess an odour more or less approaching to that of Rose or to Rose Geranium. These are:—*Ammonium salicylite*‡; *Methylbenzylenic ether*§; *Phenyl paratoluate*||; *and Phenyl benzoate.*¶ An aqueous distillate faintly approaching it results from treating methyl salicylate (oil of *gaultheria procumbens*) with caustic potash.**

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* Molina's History of Chili, i. p. 129. † Trans. Lin. Soc. xii. p. 260; Bot. Reg. p. 485; Hort. Trans. ii. t. 18. ‡ Ann. Chem. Pharm. xxix. p. 309. § Ibid. cii. p. 356. || Ibid. clxii. p. 339, and ccv. p. 113; also Chem. Central. 1859, p. 84. ¶ Jahresber. 1879, p. 675. ** Besides the journals above quoted, which detail in full the original investigations, abstracts indicating the methods of preparation, are given in modern standard works on organic chemistry, such as Watts' Dict. of Chemistry, and Roscoe and Schorlemmer's Organic Chemistry; I have also given an outline of the processes in "Odorographia," i. p. 49.